doi : 10.17596/0003312

R/V MIRAI Cruise Report MR10-03

Tropical Western Pacific Ocean
May 5 – June 28, 2010

Japan Agency for Marine-Earth Science and Technology
(JAMSTEC)

Cover: A cumulus cloud with rainbow over a calm ocean – a sight of the fixed point

Verso: Picture of participants and crew, taken just before a BBQ party on 24 June.

[Contents]

1. Introduction

It is known that cumulus clouds frequently develop over a warm water pool in the tropical western Pacific Ocean in summer. These clouds sometimes organize a convective cloud system with the horizontal dimension of several hundred kilometers, and some of them occasionally develop into a tropical depression and cyclone. A huge amount of heat released from these systems drives a large-scale atmospheric circulation. This means that the cloud systems in this area act as a heat engine of the global atmosphere.

However, the mechanism governing the development of these cloud systems has not been understood yet. In particular, the relationship between the cloud systems and large-scale atmospheric disturbances, such as a Madden-Julian Oscillation (MJO) and/or an intra-seasonal variability (ISV) during an Asian summer monsoon season, is still unclear. Moreover, a role of the warm pool on the development of clouds and atmospheric disturbances is not clarified yet. For understanding the role of tropical convection on the global climate system, it is necessary to examine the processes of interaction between an oceanic mixed layer and atmospheric convection and disturbance

In the present cruise, we conducted the atmospheric and oceanic observations at the fixed point at 5.0^{o}N, 139.5^{o}E for 38 days in May and June 2010. During the stationary observation period, we conducted surface meteorological measurement, atmospheric sounding by radiosonde, Doppler radar observation, CTD casting, oceanic microstructure profiling, and ADCP current measurement as a main mission. In addition, turbulent flux measurement, Mie-scattering LIDAR, vertical-pointing cloud radar, rain and water vapor sampling, and other many observations were intensively conducted. Furthermore, before reaching the fixed point, we deployed seven high-repetition Argo floats in the vicinity of the fixed point.

This cruise report summarizes the observation items and preliminary results. In the first four sections, basic information such as cruise track, on board personnel list are described. Details of each observation are described in Section 5. Every atmospheric profiles obtained by radiosonde are also attached in Appendix

***** Remarks *****

This cruise report is a preliminary documentation as of the end of the cruise. It may not be corrected even if changes on content are found after publication. It may also be changed without notice. Data on the cruise report may be raw or not processed. Please ask the Chief Scientist for the latest information.

2. Cruise Summary

2.1 Ship

Name	Research Vessel MIRAI
L x B x D	128.6m x 19.0m x 13.2m
Gross Tonnage	8,687 tons
Call Sign	JNSR
Home Port	Mutsu, Aomori Prefecture, Japan

2.2 Cruise Code

MR10-03

2.3 Project Name (Main mission)

Observational Study on Air-Sea Interaction in the Tropical Western Pacific Ocean

2.4 Undertaking Institute

Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
2-15, Natsushima, Yokosuka, Kanagawa 237-0061, JAPAN

2.5 Chief Scientist

Hiroyuki Yamada
Tropical Climate Variability Research Program,
Research Institute for Global Change, JAMSTEC

2.6 Periods and Ports of Call

2010	May 05	departed Guam, United States
	May 12-13	called at Koror, Republic of Palau
	June 28	arrived at Moji, Japan

2.7 Research Themes of Sub-missions and Principal Investigators (PIs)

(1) Maritime aerosol optical properties from measurements of Ship-borne sky radiometer
PI Kazuma Aoki (Toyama University)

(2) Relationship between the generation of tropical cyclones by merging precipitating systems and the variability of the tropical atmosphere
PI Tetsuya Takemi (Kyoto University)

(3) On-board continuous air-sea eddy flux measurement
PI Osamu Tsukamoto (Okayama University)

(4) Study of ocean circulation and heat and freshwater transport and their variability, and experimental comprehensive study of physical, chemical, and biochemical processes in the western North Pacific by the deployment of Argo floats and using Argo data
PI Toshio Suga (JAMSTEC / Tohoku University)

(5) Dynamics of nutrients and associated biological productivity in the oligotrophic subtropical ocean
PI Ken Furuya (The University of Tokyo)

(6) Distribution and ecology of oceanic *Halobates* inhabiting western tropical area in the pacific ocean and their responding system to several environmental factors.
PI : Tetsuo Harada (Kochi University)

(7) Identification of magnetic anomaly lineations of the Pacific Plate near the southern Mariana Trench
PI : Masao Nakanishi (Chiba University)

(8) Water sampling for building water isotopologue map over the Ocean
PI : Naoyuki Kurita (JAMSTEC)
(9) Lidar observations of optical characteristics and vertical distribution of aerosols and clouds
PI : Nobuo Sugimoto (National Institute for Environmental Studies)
(10) Structure of precipitation systems and their interaction to the atmospheric environment over the tropical western Pacific Ocean
PI : Taro Shinoda (Nagoya University)
(11) Standardising the marine geophysics data and its application to the ocean floor geodynamics studies
PI : Takeshi Matsumoto (University of the Ryukyus)
(12) Distribution and Configuration of Clouds in Various Oceans
Toshiaki Takano (Chiba University)

2.8 Observation Summary

GPS Radiosonde	360 times	from May 6 to June 27
5.3-GHz Doppler radar	continuously	from May 6 to June 26
95-GHz cloud profiling radar	continuously	from May 6 to June 27
Mie-scattering LIDAR	continuously	from May 6 to June 27
Ceilometer	continuously	from May 5 to June 27
GPS Meteorology	continuously	from May 5 to June 27
Infrared radiometer	continuously	from May 6 to June 27
Sky Radiometer	continuously	from May 6 to June 27
Rain and water vapor sampling	continuously	from May 5 to June 27
Surface Meteorology	continuously	from May 5 to June 27
Atmospheric turbulent flux	continuously	from May 6 to June 27
Sea surface water monitoring	continuously	from May 6 to June 27
CTDO profiling	304 times	from May 6 to June 22
Sea water sampling	36 times	from May 16 to June 22
Photosynthetically active radiation	18 times	from May 16 to June 19
Argo float deployment	7 times	from May 5 to May 13
Oceanic microstructure profiling	118 times	from May 6 to June 20
Shipboard ADCP	continuously	from May 6 to June 27
Gravity/Magnetic force	continuously	from May 5 to June 27
Topography	continuously	from May 5 to June 27
Sea skater sampling	30 times	from May 16 to June 20

2.9 Overview

In order to investigate the atmospheric and oceanic conditions in the tropical western Pacific Ocean in the boreal summer season, the intensive observations were carried out. First, we deployed 7 Argo floats within an area between 133.5 and 142.5^{o}E and between 6 and 17^{o}N. Then, we conducted the observations at a fixed site at 5.0^{o}N, 139.5^{o}E from May 16 through June 22 (38 days).

Although winds in the lower troposphere were mostly easterly throughout the observation period, significant changes in the convective activity and ocean structure were observed at the fixed point. During the first half month of observation period, convective activity was continuously high due to the development of convective clouds over the intertropical convergence zone (ITCZ). In the following half month, convective activity varied periodically in a 4-5 day cycle. This change related to the passage of equatorial waves/disturbances during a convectively inactive phase before the onset of Asian summer monsoon. In the remaining period, deep convective cloud systems much developed due to the eastward propagation of an intra-seasonal variation (ISV) from the Indian Ocean to the western Pacific. At the same time, the northward propagation of a convectively-active area was also significant in the western Pacific. These changes in the convective activity in the observational area can be confirmed by the time series of Doppler radar echo area (see Fig. 5.2-1). The GPS radiosonde observation captured a negative anomaly of temperature in the upper troposphere in 15-20 June (Fig.5.1-1), which suggests the predominance of large-scale upward motion associated with the ISV.

Changes in the structure of the oceanic surface layer, related with the atmospheric variation, were observed by CTDO profiling and Argo-float observations. A warming of surface mixed layer in May, followed by cooling in June, can be seen in Figs. 5.13-2 and 5.18-2. The CTD data (Figs. 5.13-2) also show a significant change in salinity in a sub-surface layer (100-200m depth) at the fixed point, which suggests an intrusion of water with high salinity from the south.

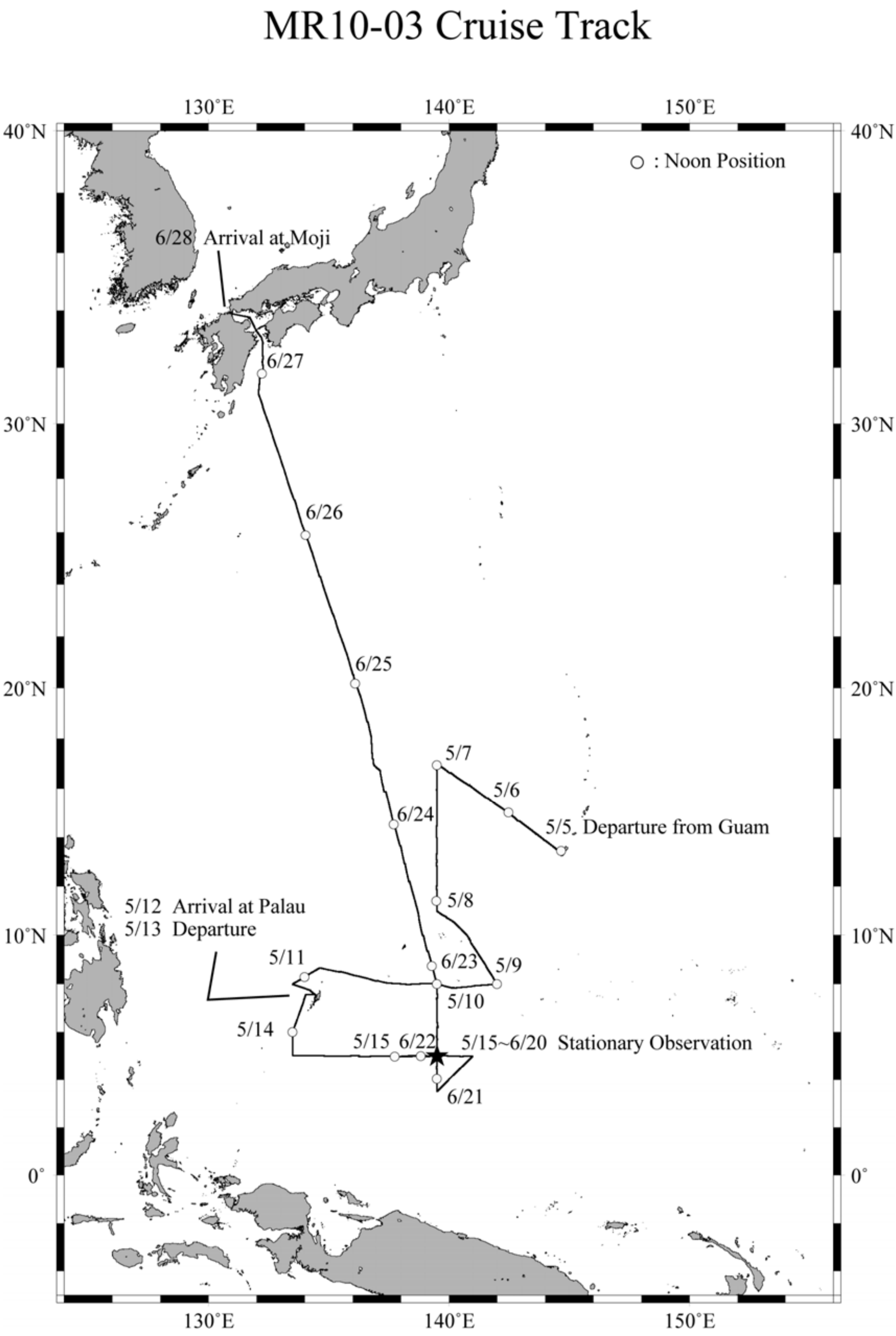
These features suggest that the changes in the atmospheric and oceanographic conditions, associated with ISV in a boreal summer over the tropical western Pacific, were successfully captured by the observation at the fixed point.

2.10 Acknowledgments

We would like to express our sincere thanks to Captain Y. Ishioka and his crew for their skillful ship operation. Thanks are extended to the technical staff of Global Ocean Development Inc. and Marine Works Japan, Ltd. for their continuous support to conduct the observations.

3. Cruise Track and Log

3.1 Cruise Track



3.2 Cruise Log

*Note
All timestamps are in UTC+9h, except in May 5 (UTC+10h).
The time in the ship changes at 1200UTC, May 05, from UTC+10h to UTC+9h.

3.2.1 Leg-1

Date	Time*	Event
May 05	1400	Depart Guam, U.S.
May 06	0606	Arrive point (15N, 142.5E)
	0851	Deploy ARGO float
	0854	Depart point (15N, 142.5E)
	1300	Start Doppler radar observation
	1300	Start surface water monitoring
	1430	Launch radiosonde
	2030	Launch radiosonde
May 07	0231	Launch radiosonde
	0700	Arrive point (17N, 139.5E)
	0733	CTDO (500m)
	0806	MSP
	0833	Launch radiosonde
	0839	Deploy ARGO float
	0842	Depart point (17N, 139.5E)
	1430	Launch radiosonde
	2030	Launch radiosonde
May 08	0230	Launch radiosonde
	0830	Launch radiosonde
	1042	Arrive point (11N, 139.5E)
	1044	CTDO (500m)
	1118	MSP
	1145	Deploy ARGO float
	1148	Depart point (11N, 139.5E)
May 09	1430	Launch radiosonde
	1827	Collecting Seaer
	2032	Launch radiosonde
May 10	0229	Launch radiosonde
	0400	Arrive point (8N, 139.5E)
	0730	CTDO (500m)
	0802	MSP
	0830	Launch radiosonde
	0832	Deploy ARGO float
	0842	Freefall of clean-cable water sampler (1000m)
	1000	Depart point (8N, 139.5E)発
	1431	Launch radiosonde
	2031	Launch radiosonde
May 11	0230	Launch radiosonde

	0830	Launch radiosonde
	1200	Arrive point (8N, 133.5E)
	1301	CTDO (500m)
	1334	MSP
	1403	Deploy ARGO float
	1406	Depart point (8N, 133.5E)
	1431	Launch radiosonde
	1530	Pause surface water monitoring
May 12	0800	Pause Doppler radar observation
	1300	Arrive Koror, Palau

3.2.2 Leg-2

3.2.2-1 Before Arriving Station (5N, 139.5E)

Date	Time*	Event
May 13	1300	Depart Koror, Palau
	1600	Resume surface water monitoring
	1700	Resume Doppler radar observation
	1804	Testing 3-dimensional magnetometer
May 14	0803	CTDO (500m) at (6N,133.5E)
	0833	Launch radiosonde at (6.00N, 139.50E)
	0843	MSP (300m) at (6N,133.5E)
	0909	Deploy ARGO float at (6N,133.5E)
	1354	CTDO (500m) at (5N,133.5E)
	1428	Launch radiosonde at (5.00N, 133.50E)
	1433	MSP (300m) at (5N,133.5E)
	2030	Launch radiosonde at (5.02N, 134.75E)
May 15	0230	Launch radiosonde at (5.02N, 135.03E)
	0830	Launch radiosonde at (5.00N, 137.62E)
	1430	Launch radiosonde at (5.01N, 138.96E)

3.2.2-2 At Station (5N, 139.5E)

Date	Time*	Event
May 15	1630	**Arrive stationary observation point (5N,139.5E) (stay to 21SMT, Jun.20)**
	1730	Start 3-hourly radiosonde observation at (5N, 139.5E) (to 21SMT, Jun.20)
May 16	0740	Profiling light intensity (down to 100m)
	0834	Start 3-hourly CTDO observation (down to 500m) at (5N, 139.5E) (to 21SMT, Jun.20)
	0927	Start 12-hourly MSP observation (down to 300m) at (5N, 139.5E) (to 22SMT, Jun.20)
	0955	Start 3-hourly atmospheric turbulent flux measurement around (5N, 139.5E) (to 21SMT, Jun.20)
	1030	Deploy “Sea Snake” SSST sensor
	1855	Collecting sea-skater
May 17	1856	Collecting sea-skater
May 18	0802	Profiling light intensity (100m)
	1840	Collecting sea-skater
May 20	0802	Profiling light intensity (100m)

	1840	Collecting sea-skater
May 21	1838	Collecting sea-skater
May 22	0800	Profiling light intensity (100m)
	1843	Collecting sea-skater
May 23	1840	Collecting sea-skater
May 24	0800	Profiling light intensity (100m)
	0932	Start 3-hourly MSP observation (300m) (to 09SMT, May 27)
May 25	1845	Collecting sea-skater
May 26	0800	Profiling light intensity (100m)
	1848	Collecting sea-skater
May 27	0801	CTDO (1000m)
	0913	Last of 3-hourly MSP observation from 09SMT May 24 (back to 12-hourly)
	1838	Collecting sea-skater
May 28	0801	Profiling light intensity (100m)
	1836	Collecting sea-skater
May 30	0800	Profiling light intensity (100m)
	1836	Collecting sea-skater
May 31	1836	Collecting sea-skater
Jun.01	0759	Profiling light intensity (100m)
	1837	Collecting sea-skater
Jun.02	0802	CTDO (1000m)
Jun.03	0800	Profiling light intensity (100m)
	1840	Collecting sea-skater
Jun.04	1838	Collecting sea-skater
Jun.05	0800	Profiling light intensity (100m)
	1837	Collecting sea-skater
Jun.07	0759	Profiling light intensity (100m)
	0930	Start 3-hourly MSP observation (300m) (to 09SMT, Jun.10)
	1841	Collecting sea-skater
Jun.08	0800	CTDO (1000m)
	1840	Collecting sea-skater
Jun.09	0802	Profiling light intensity (100m)
	1402	CTDO (1000m)
	1905	Collecting sea-skater
Jun.10	0925	Last of 3-hourly MSP observation from 09SMT Jun.07 (back to 12-hourly)
Jun.11	0801	Profiling light intensity (100m)
	1836	Collecting sea-skater
Jun.12	1838	Collecting sea-skater
Jun.13	0800	Profiling light intensity (100m)
	1837	Collecting sea-skater
Jun.14	0800	CTDO (1000m)
Jun.15	0800	Profiling light intensity (100m)
	1838	Collecting sea-skater
Jun.16	1836	Collecting sea-skater
Jun.17	0800	Profiling light intensity (100m)
	1836	Collecting sea-skater
Jun.19	0800	Profiling light intensity (100m)
	1837	Collecting sea-skater
Jun.20	0800	CTDO (1000m)

	1520	Recover “Sea Snake” SSST sensor
	1810	Last of 3-hourly atmospheric turbulent flux measurement (from 09SMT, May 16)
	1837	Collecting sea-skater
	2030	Last of 3-hourly radiosonde observation at (5N, 139.5E) (from 18SMT, May 15)
	2037	Last of 3-hourly CTDO observation (500m) (from 09SMT, May 16)
	2110	Last of 12-hourly MSP observation (300m) (from 09SMT, May 16)
	2142	**Depart stationary observation point (5N, 139.5E)**

3.2.2-3 After Leaving Station (5N, 139.5E)

Date	Time*	Event
Jun.20	2330	Launch radiosonde at (5.00N, 139.15E)
Jun.21	0230	Launch radiosonde at (5.01N, 138.38E)
	0358	CTDO (500m) at (5N, 138E)
	0530	Launch radiosonde at (5.00N, 138.14E)
	0800	CTDO (500m) at (5N, 138.75E)
	0830	Launch radiosonde at (5.00N, 138.75E)
	1130	Launch radiosonde at (5.00N, 139.36E)
	1202	CTDO (500m) at (5N, 139.5E)
	1430	Launch radiosonde at (5.01N, 139.88E)
	1556	CTDO (500m) at (5N, 140.25E)
	1730	Launch radiosonde at (5.00N, 140.42E)
	2001	CTDO (500m) at (5N, 141E)
	2031	Launch radiosonde at (5.00N, 141.00E)
	2331	Launch radiosonde at (4.57N, 140.57E)
Jun.22	0230	Launch radiosonde at (4.03N, 140.02E)
	0531	Launch radiosonde at (3.57N, 139.57E)
	0558	CTDO observation (500m) at (3.5N, 139.5E)
	0830	Launch radiosonde at (3.91N, 139.50E)
	1001	CTDO (500m) at (4.25N, 139.5E)
	1129	Launch radiosonde at (4.39N, 139.50E)
	1358	CTDO (500m) at (5N,139.5E)
	1430	Launch radiosonde at (5.00N, 139.50E)
	1730	Launch radiosonde at (5.65N, 139.50E)
	1803	CTDO (500m) at (5.75N,139.5E)
	2030	Launch radiosonde at (6.14N, 139.50E)
	2200	CTDO (500m) at (6.5N,139.5E)
	2330	Launch radiosonde at (6.64N, 139.50E)
Jun.23	0230	Launch radiosonde at (7.36N, 139.50E)
	0502	CTDO (500m) at (8N, 139.5E)
	0531	Launch radiosonde at (8.00N, 139.50E)
	0830	Launch radiosonde at (8.60N, 139.35E)
	1144	Launch radiosonde at (9.36N, 139.13E)
	1431	Launch radiosonde at (9.93N, 138.96E)
	1730	Launch radiosonde at (10.64N, 138.76E)
	2030	Launch radiosonde at (11.38N, 138.60E)
	2330	Launch radiosonde at (12.14N, 138.39E)
Jun.24	0231	Launch radiosonde at (12.87N, 138.19E)
	0530	Launch radiosonde at (13.61N, 138.01E)

	0830	Launch radiosonde at (14.33N, 137.79E)
		(Last of 3-hourly observation: switch to 6-hourly observation)
	1430	Launch radiosonde at (15.84N, 137.39E)
	2030	Launch radiosonde at (17.12N, 136.85E)
Jun.25	0230	Launch radiosonde at (18.59N, 136.65E)
	0830	Launch radiosonde at (19.97N, 136.20E)
	1021	Testing 3-dimensional magnetometer
	1430	Launch radiosonde at (21.33N, 135.75E)
	2030	Launch radiosonde at (22.80N, 135.21E)
Jun.26	0230	Launch radiosonde at (24.22N, 134.68E)
	0830	Launch radiosonde at (25.68N, 134.13E)
	1430	Launch radiosonde at (27.16N, 133.60E)
	1525	Finish surface water monitoring
	2030	Launch radiosonde at (28.55N, 133.06E)
	2200	Finish Doppler radar observation
Jun.27	0230	Launch radiosonde at (30.00N, 132.51E)
	0830	Launch radiosonde at (31.56N, 132.13E)
		(Last of radiosonde observation)
Jun.28	0730	Arrive Moji

4. List of Participants

4.1 Participants (on board)

Name	Affiliation	*Theme No.	Period on board
Hiroyuki YAMADA	JAMSTEC	M	Leg-1/2
Biao GENG	JAMSTEC	M	Leg-1/2
Masaki KATSUMATA	JAMSTEC	M	Leg-1/2
Sho ARAKANE	JAMSTEC / U. Tokyo	M	Leg-1/2
Masaki SATOH	JAMSTEC / U. Tokyo	M	Leg-1
Dariusz BARANOWSKI	Univ. Warsaw	M	Leg-1
Ryuji YOSHIDA	Kyoto Univ.	2	Leg-2
Takako MASUDA	U. Tokyo	5	Leg-1/2
Xin LIU	U. Tokyo	5	Leg-1/2
Tetsuo HARADA	Kochi Univ.	6	Leg-1
Takero SEKIMOTO	Kochi Univ.	6	Leg-1/2
Kohki IYOTA	Kochi Univ.	6	Leg-1/2
Yuki OSUMI	Kochi Univ.	6	Leg-1/2
Satoki TSUJINO	Nagoya Univ.	8	Leg-1/2
Hiroshi UYEDA	Nagoya Univ.	8	Leg-1
Toshiaki TAKANO	Chiba Univ.	11	Leg-1
Shusuke MORIYA	Chiba Univ.	11	Leg-1
Shinji NAKAYAMA	Chiba Univ.	11	Leg-2
Souichiro SUEYOSHI	Global Ocean Development Inc. (GODI)	T	Leg-1/2
Harumi OTA	GODI	T	Leg-1/2
Asuka DOI	GODI	T	Leg-1/2
Ken’ichi KATAYAMA	Marine Works Japan Ltd. (MWJ)	T	Leg-1/2
Fujio KOBAYASHI	MWJ	T	Leg-1/2
Hironori SATOH	MWJ	T	Leg-1/2
Naoko TAKAHASHI	MWJ	T	Leg-2
Tatsuya TANAKA	MWJ	T	Leg-2
Shungo OSHITANI	MWJ	T	Leg-2
Tamami UENO	MWJ	T	Leg-2
Shin’ichiro YOKOGAWA	MWJ	T	Leg-2
Masanori ENOKI	MWJ	T	Leg-2
Tadashi KATO	Hydro Systems Development Inc.	T	Leg-1
Timo WITTE	OPTIMARE Sensorsysteme GmbH	T	Leg-1

* Theme number corresponds to that shown in Section 2.7.
M and T means main mission and technical staff, respectively.

4.2 Participants (not on board)

Name	Affiliation	*Theme No.
Kazuma AOKI	Toyama Univ.	1
Tadahiro HAYASAKA	Tohoku Univ.	1
Tetsuya TAKEMI	Kyoto Univ.	2
Osamu TSUKAMOTO	Okayama Univ.	3
Hiroshi ISHIDA	Kobe Univ.	3
Fumiyoshi KONDO	U. Tokyo	3
Toshio SUGA	JAMSTEC	4
Ken FURUYA	U. Tokyo	5
Taketoshi KODAMA	U. Tokyo	5
Chihiro KATAGIRI	Hokkaido Univ.	6
Naoyuki KURITA	JAMSTEC	7
Nobuo SUGIMOTO	NIES	8
Taro SHINODA	Nagoya Univ.	9
Takeshi MATSUMOTO	Ryukyu Univ.	10
Hajime OKAMOTO	Tohoku Univ.	11

4.2 Ship Crew

Yasushi ISHIOKA	Master
Takeshi ISOHI	Chief Officer
Norichika WATANABE	First Officer
Takao NAKAYAMA	Jr. First Officer
Nobuo FUKAURA	Second Officer
Hirokazu SUGAWARA	Third Officer
Yoichi FURUKAWA	Chief Engineer
Koji MASUNO	First Engineer
Hiroyuki TOHKEN	Second Engineer
Keisuke NAKAMURA	Third Engineer
Ryo OHYAMA	Technical Officer
Yosuke KUWAHARA	Boatswain
Ryoji SAKAI	Able Seaman
Yasuhiro ITO	Able Seaman
Tsuyoshi SATOH	Able Seaman
Takeharu AISAKA	Able Seaman
Tsuyoshi MONZAWA	Able Seaman
Masashige OKADA	Able Seaman
Hideaki TAMOTSU	Ordinary Seaman
Hideyuki OKUBO	Ordinary Seaman
Ginta OGAKI	Ordinary Seaman
Masaya TANIKAWA	Ordinary Seaman
Shohei UEHARA	Ordinary Seaman
Kazunari MITSUNAGA	Ordinary Seaman
Tomohiro SHIMADA	Ordinary Seaman
Yukitoshi HORIUCHI	No.1 Oiler
Toshimi YOSHIKAWA	Oiler
Yoshihiro SUGIMOTO	Oiler
Nobuo BOSHITA	Oiler
Kazumi YAMASHITA	Oiler
Keisuke YOSHIDA	Ordinary Oiler
Hiromi IKUTA	Ordinary Oiler
Shintaro ABE	Ordinary Oiler
Hitoshi OTA	Chief Steward
Tamotsu UEMURA	Cook
Sakae HOSHIKUMA	Cook
Michihiro MORI	Cook
Kozo UEMURA	Cook
Kanjuro MURAKAMI	Cook
Shohei MARUYAMA	Steward

5. Summary of the Observations

5.1 GPS Radiosonde

(1) Personnel

Hiroyuki YAMADA	(JAMSTEC)	*Principal Investigator
Biao GENG	(JAMSTEC)	
Masaki KATSUMATA	(JAMSTEC)	
Sho ARAKANE	(JAMSTEC / Univ. Tokyo)	
Masaki SATOH	(JAMSTEC / Univ. Tokyo)	
Ryuji YOSHIDA	(Kyoto Univ.)	
Tetsuya TAKEMI	(Kyoto Univ.)	*not on board
Satoki TSUJINO	(Nagoya Univ.)	
Hiroshi UYEDA	(Nagoya Univ.)	
Taro SHINODA	(Nagoya Univ.)	*not on board
Souichiro SUEYOSHI	(GODI)	*Operation Leader
Harumi OTA	(GODI)	
Asuka DOI	(GODI)	
Ryo OHYAMA	(Mirai crew)	

(2) Objectives

To obtain atmospheric profile of temperature, humidity, and wind speed/direction, and their temporal variations

(3) Methods

Atmospheric sounding by radiosonde was carried out every 3 hours from 06UTC on May 15, 2010 to 00UTC on June 24, 2010, including stationary observation period at (5N, 139.5E). In addition, the radiosonde was launched every 6 hourly during the periods (1) from 06UTC on May 6 to 06UTC on May 11, (2) from 00UTC on May 14 to 00UTC on May 15, and (3) from 06UTC on June 24 to 00UTC on June 27. In total, 360 soundings were carried out, as listed in Table 5.1-1.

The GPS radiosonde sensor (RS92-SGPD) was launched with the balloons (Totex TA-200/300/350). The on-board system to calibrate, to launch, to log the data and to process the data, consists of processor (Vaisala, DigiCORA III), GPS antenna (GA20), UHF antenna (RB21), ground check kit (GC25), and balloon launcher (ASAP).

(4) Results

Figure 5.1-1 is the time-height cross sections during the stationary observation period at (5N, 139.5E) for equivalent potential temperature, relative humidity, zonal and meridional wind components. Several basic parameters are derived from sounding data as in Fig. 5.1-2, including convective available potential energy (CAPE), convective inhibition (CIN), lifted condensation level (LCL), level of free convection (LFC), and total precipitable water vapor (TPW). Each vertical profiles of temperature and dew point temperature on the thermodynamic chart with wind profiles are attached in Appendix-A.

(5) Data archive

Data were sent to the world meteorological community via Global Telecommunication System (GTS) through the Japan Meteorological Agency, immediately after each observation. Raw data is recorded as ASCII format every 2 seconds during ascent. These raw datasets will be submitted to JAMSTEC Data Integration and Analyses Group. The corrected datasets are available from Mirai Web site at http://www.jamstec.go.jp/cruisedata/mirai/e/.

Table 5.1-1: Radiosonde launch log, with surface values and maximum height.

ID	Date	Launched Location		Surface States					Max. height	Cloud at Launch	
		Latitude	Longitude	P	T	RH	WD	WS		Am.	Type
		degN	degE	hPa	degC	%	deg	m/s	m		
Leg1											
RS004	2010050606	15.603	141.625	1006.5	28.0	80	95	4.9	24199	2	As, Cu, Sc
RS005	2010050612	16.109	140.881	1008.6	27.9	79	89	7.3	4720	4	Sc, Cu
RS006	2010050618	16.622	140.090	1007.7	27.5	79	90	7.8	23641	1	–
RS007	2010050700	17.000	139.503	1009.2	27.9	76	86	4.9	27088	5	Cu, Sc
RS008	2010050706	16.014	139.512	1005.9	28.4	69	88	6.9	27071	2	Cu, Sc
RS009	2010050712	14.529	139.499	1007.4	27.8	74	93	6.9	25170	3	Cu
RS010	2010050718	13.047	139.499	1005.8	27.8	77	71	9.2	23732	4	Cu
RS011	2010050800	11.600	139.499	1006.2	28.0	72	82	10.1	23867	8	Cu, Sc, As
RS012	2010050806	10.770	139.856	1003.3	28.2	73	61	7.1	25985	10	Cu, Sc, As
RS013	2010050812	9.816	140.875	1005.3	28.2	77	73	10.4	22925	3	Cu
RS014	2010050818	8.782	141.525	1003.7	28.2	75	71	8.1	23629	5	Sc
RS015	2010050900	8.000	142.003	1005.4	29.1	64	90	8.5	24720	9	Cs, Cu, Sc
RS016	2010050906	7.918	141.005	1001.9	29.8	70	72	9.0	26538	8	As, Sc
RS017	2010050912	7.844	140.187	1004.8	28.8	75	75	8.0	24902	7	Sc
RS018	2010050918	7.958	139.670	1003.6	28.7	76	76	10.6	26566	5	Sc, Cu
RS019	2010051000	8.003	139.500	1005.7	29.3	63	77	11.3	27737	8	Ci, Ac, Cu
RS020	2010051006	8.001	138.487	1002.4	29.6	64	85	10.1	26466	6	Ci, Cu, Sc
RS021	2010051012	8.115	137.103	1006.5	29.0	68	86	8.8	26921	5	Cu, Sc
RS022	2010051018	8.501	135.536	1005.0	28.6	69	82	8.9	27585	4	–
RS023	2010051100	8.379	134.137	1007.3	29.3	69	62	8.7	24408	9	Ci, Cu
RS024	2010051106	8.003	133.519	1004.6	29.3	63	57	9.1	22902	4	Ci, As
Leg2											
RS025	2010051400	6.001	133.499	1005.6	29.0	76	72	6.8	25753	7	Cu, Ac, Sc
RS026	2010051406	5.004	133.502	1003.0	29.7	74	81	8.4	25324	7	Cu, Sc, As, Cc
RS027	2010051412	5.018	134.745	1004.7	28.5	78	68	6.8	24872	4	–
RS028	2010051418	5.022	135.027	1003.5	29.1	76	83	7.9	23684	1	–
RS029	2010051500	5.000	137.616	1005.4	27.8	80	60	4.8	25502	8	Cu, Sc, Ac
RS030	2010051506	5.009	138.962	1003.5	29.6	69	101	4.6	25196	8	Cu, Sc
RS031	2010051509	5.015	139.497	1003.8	29.6	73	89	4.2	23259	7	Cu, Sc, Cs, As
RS032	2010051512	5.011	139.501	1005.2	29.4	71	90	4.8	23854	5	Sc
RS033	2010051515	4.988	139.505	1005.3	29.2	73	79	4.5	24272	8	Sc, Cu
RS034	2010051518	5.009	139.495	1004.4	28.9	75	77	3.9	24421	7	–
RS035	2010051521	5.000	139.506	1004.9	28.9	75	70	4.2	24436	7	Cu, Sc, Ac
RS036	2010051600	5.000	139.501	1006.0	29.5	72	61	3.3	24919	6	Cu, Sc, As
RS037	2010051603	5.006	139.512	1005.5	29.3	72	63	5.8	23824	9	Cu, Sc, As, Ac
RS038	2010051606	5.010	139.511	1004.0	28.5	78	84	9.3	23180	9	Ac, Cu, Sc
RS039	2010051609	5.009	139.504	1003.7	28.3	79	53	8.1	25626	6	Cu, Sc, As, Cs
RS040	2010051612	5.013	139.523	1005.6	28.7	77	85	8.1	24222	9	–
RS041	2010051615	5.000	139.502	1005.9	28.7	79	95	6.5	23702	5	–
RS042	2010051618	5.001	139.514	1005.3	28.8	78	92	5.8	22750	3	–
RS043	2010051621	4.999	139.502	1005.6	28.9	75	85	6.1	24565	7	Cu, Sc, Ac, Cc, Ns
RS044	2010051700	5.001	139.503	1006.6	29.3	73	76	5.3	25225	8	Cu, Sc, Ac, As, Ns
RS045	2010051703	5.001	139.506	1006.2	29.6	73	89	6.4	25503	7	Cu, Sc, As, Ac, Cc, Ci

RS046	2010051706	5.000	139.499	1004.7	29.6	70	78	8.2	23809	5	Cu, Sc
RS047	2010051709	5.004	139.504	1004.9	29.3	76	75	6.9	24899	5	Sc, Cu, As
RS048	2010051712	4.985	139.505	1006.7	29.3	77	63	6.0	22958	6	–
RS049	2010051715	5.003	139.507	1006.8	29.2	74	62	5.7	24848	3	–
RS050	2010051718	5.020	139.516	1005.7	28.9	73	57	5.6	23629	2	–
RS051	2010051721	5.010	139.509	1005.8	28.8	74	41	5.5	24453	4	–
RS052	2010051800	5.001	139.501	1006.7	29.5	73	54	4.6	25319	5	Cu, As
RS053	2020051803	5.007	139.506	1006.0	29.5	71	27	7.4	24228	7	Cu, Sc, Cs, Ac
RS054	2010051806	5.012	139.507	1004.8	30.0	72	53	4.0	24186	5	Cu, Ac, Cs
RS055	2010051809	5.008	139.503	1005.5	28.7	76	84	7.3	21621	9	As, Cu, Sc, Cs, Ns
RS056	2010051812	4.999	139.517	1007.7	29.5	72	73	5.1	20161	4	–
RS057	2010051815	5.001	139.500	1007.4	29.1	76	76	6.5	27040	8	–
RS058	2010051818	5.001	139.512	1005.7	29.0	75	97	2.9	24064	6	–
RS059	2010051821	5.004	139.513	1005.9	28.9	76	55	2.3	28348	8	Cu, Sc, Ac, As, Cs
RS060	2010051900	5.019	139.503	1006.6	29.5	74	25	4.1	25846	9	Cu, As, Sc, Ac
RS061	2010051903	5.010	139.504	1006.6	29.8	75	34	5.4	27908	8	Cu, As, Ac
RS062	2010051906	5.010	139.510	1005.7	28.4	74	49	4.5	25226	9	Cu
RS063	2010051909	5.006	139.507	1006.3	29.4	71	82	4.4	28675	7	Cu, As, Ac
RS064	2010051912	5.005	139.510	1007.8	29.3	74	96	4.7	23755	7	Cu, As
RS065	2010051915	5.001	139.502	1007.2	29.2	75	76	5.1	24492	2	–
RS066	2010051918	5.012	139.517	1006.0	28.6	80	100	5.4	19055	8	–
RS067	2010051921	5.007	139.509	1006.7	27.5	82	17	5.4	24901	10	Cu, Ac, As, Sc, Nb
RS068	2010052000	5.001	139.502	1008.4	27.9	83	157	1.4	24897	10	Cu, Sc
RS069	2010052003	5.012	139.504	1007.1	27.7	80	57	0.8	25924	7	Cu, Sc, As, Ac, Cs
RS070	2010052006	5.020	139.508	1005.2	28.8	77	53	2.9	24454	6	Cu, As
RS071	2010052009	5.008	139.512	1006.5	28.6	79	23	2.8	23943	9	Cu, Ci, As, Ac
RS072	2010052012	5.001	139.513	1007.9	28.7	79	87	2.7	22473	7	As, Cu, Sc
RS073	2010052015	5.006	139.508	1007.6	28.1	81	349	0.4	23853	9	–
RS074	2010052018	5.018	139.501	1005.8	27.4	80	305	2.3	22326	9	–
RS075	2010052021	5.013	139.499	1006.9	26.6	88	49	6.0	26672	9	Cu, Sc, Ns
RS076	2010052100	5.013	139.998	1007.8	28.4	82	42	7.2	25501	10	Cu, Sc, As, Ac
RS077	2010052103	5.010	139.505	1006.1	28.7	79	50	7.3	24102	7	Cu
RS078	2010052106	5.014	139.520	1004.2	28.6	74	75	5.2	25142	8	Cu, Ns, As, Sc
RS079	2010052109	5.004	139.514	1004.8	28.6	78	65	5.2	25374	9	Cu, As, Ci, Cs
RS080	2010052112	4.995	139.516	1006.7	29.0	77	74	5.0	23345	7	Cu, As
RS081	2010052115	4.993	139.496	1005.9	29.0	78	75	7.7	22645	3	Sc, Cu
RS082	2010052118	4.999	139.519	1005.1	28.6	75	88	6.2	17150	9	–
RS083	2010052121	5.000	139.503	1005.7	28.0	82	93	7.9	26849	10	Cu, As, Sc, Ns
RS084	2010052200	5.002	139.501	1006.9	28.3	83	144	4.7	24628	10	Cu, Sc, Ns
RS085	2010052203	5.000	139.502	1006.1	28.4	80	173	3.8	24523	10	Ns, Cu, Sc
RS086	2010052206	4.978	139.505	1004.3	29.0	78	131	3.7	26968	9	Cu, Sc, As
RS087	2010052209	5.000	139.502	1005.3	28.8	78	136	3.3	22260	9	As, Cu, Ci, Ns, Cc
RS088	2010052212	5.006	139.495	1006.6	29.0	72	120	3.2	23868	5	Sc, Cu
RS089	2010052215	5.002	139.495	1006.6	28.9	74	93	2.3	23844	3	Sc
RS090	2010052218	5.010	139.517	1005.8	28.6	77	106	4.1	23859	6	–
RS091	2010052221	4.998	139.514	1006.3	27.7	80	72	3.9	24202	7	Cu,Sc,As,Cc,Ci
RS092	2010052300	4.999	139.500	1007.9	28.8	76	90	2.3	24208	4	Cu, Sc, Ac, As, Cc
RS093	2010052303	5.007	139.510	1006.6	29.4	74	77	3.2	21423	4	Cu, Cs, Sc, As
RS094	2010052306	4.994	139.509	1005.1	25.8	89	175	1.0	23895	8	Ns, Cb, Cu, Ac, Cs

RS095	2010052309	4.991	139.504	1006.1	27.1	81	9	5.2	23177	9	Cu, Ns, As, Sc, Cs
RS096	2010052312	4.998	139.508	1007.8	26.7	85	23	5.4	21062	9	Sc, Cu?
RS097	2010052315	5.007	139.500	1007.9	26.2	84	114	3.3	19667	9	Cu?
RS098	2010052318	4.983	139.514	1006.1	27.4	80	93	2.2	22794	8	Sc?
RS099	2010052321	5.000	139.513	1006.6	27.9	81	105	4.4	25179	3	Cu,Sc,As,Ns,Cc,Ci
RS100	2010052400	5.000	139.501	1008.1	29.0	77	121	4.6	25419	3	Cu,Sc,As
RS101	2010052403	5.001	139.509	1007.5	29.6	74	118	3.1	23850	4	Cu,Nb,Ci,Sc
RS102	2010052406	4.994	139.526	1006.3	29.5	73	132	2.6	25190	3	Cu,Ac,As
RS103	2010052409	5.002	139.516	1006.9	29.0	78	72	1.3	23577	4	Cu, Sc, As
RS104	2010052412	4.999	139.513	1008.7	28.9	78	318	1.1	24735	8	Cu, Sc, As
RS105	2010052415	5.012	139.500	1008.4	27.4	81	148	2.2	24107	6	As, Sc, Cu
RS106	2010052418	4.989	139.506	1006.4	27.8	81	112	1.6	22475	–	–
RS107	2010052421	5.010	139.508	1006.8	27.5	81	345	3.3	25582	4	Cu,Sc,As,Ac,Ci
RS108	2010052500	5.014	139.501	1008.9	28.5	77	42	2.7	25399	3	Cu,Sc,As,Cs
RS109	2010052503	5.006	139.514	1008.4	28.6	70	98	6.7	25389	10	Ns,Cu,Sc
RS110	2010052506	4.998	139.510	1006.3	26.9	83	81	4.2	25271	10	Ns, Sc, Cu
RS111	2010052509	4.997	139.508	1006.5	28.0	76	76	7.8	23934	9	Ac, Cu
RS112	2010052512	5.001	139.511	1007.8	28.6	79	36	5.5	22773	9	Sc, Cu
RS113	2010052515	5.010	139.504	1007.6	28.9	74	64	6.1	22206	9	As, Cu
RS114	2010052518	5.010	139.510	1006.0	28.7	78	88	6.7	23629	5	Sc, Cu
RS115	2010052521	5.000	139.511	1006.5	28.9	72	93	6.8	25927	7	Cu,Sc,Ac,Cc
RS116	2010052600	4.998	139.499	1008.0	29.8	70	95	8.4	25355	4	Cu,Ac,As,Sc
RS117	2010052603	5.000	139.513	1006.6	29.6	72	101	6.5	25348	5	Cu, Sc
RS118	2010052606	5.006	139.516	1004.9	29.4	74	83	8.4	24528	9	Cu, Sc, Nb, As
RS119	2010052609	5.000	139.501	1006.0	27.5	85	91	2.6	19263	9	Cu, Ns, Ac, As, Sc
RS120	2010052612	4.997	139.510	1008.3	28.4	78	72	3.7	22643	6	Sc, Cu
RS121	2010052615	5.002	139.505	1008.6	27.0	79	130	10.2	20883	10	Cu
RS122	2010052618	5.014	139.512	1007.0	28.2	79	63	3.5	22441	7	Sc, As, Cu
RS123	2010052621	5.010	139.508	1008.0	28.5	78	87	2.1	24748	9	Cu,Sc,As,Ac
RS124	2010052700	5.000	139.498	1009.5	28.3	73	171	5.5	25828	9	Cu,Sc,As,Ac
RS125	2010052703	4.997	139.504	1008.9	29.7	73	83	2.8	25322	5	Cu,Nb,As,Cs,Cc
RS126	2010052706	5.003	139.512	1006.8	29.7	74	81	3.0	24740	4	Cu,As,Ac
RS127	2010052709	5.001	139.502	1007.2	27.5	79	46	6.1	12901	7	Ci,Cu,Ns,Cc,As
RS128	2010052712	4.993	139.509	1009.6	28.8	77	52	3.5	23650	1	Cu,As
RS129	2010052715	5.005	139.506	1009.4	28.1	74	29	3.1	23949	3	Cu
RS130	2010052718	5.018	139.506	1008.0	28.5	79	41	5.1	23694	6	Cu,As
RS131	2010052721	5.012	139.514	1008.0	28.3	79	72	6.2	24818	5	Ac, Cu, Nb, Ci, Sc
RS132	2010052800	4.999	139.500	1009.3	29.4	74	52	4.9	24826	3	Cu, Sc, As
RS133	2010052803	5.003	139.508	1008.2	29.3	75	81	2.6	25435	4	Cu, Cc, Cs, As, Ac
RS134	2010052806	5.003	139.518	1007.0	30.1	71	90	3.9	24498	6	Cu, Ci, Sc, Cc
RS135	2010052809	4.994	139.512	1007.5	28.4	80	72	3.3	23802	6	Cu,As,Cs
RS136	2010052812	5.000	139.517	1009.2	27.9	82	88	5.6	24131	5	Cu,Sc,As
RS137	2010052815	4.992	139.505	1009.2	28.3	80	75	5.1	24208	6	Cu,Sc,As,Ac
RS138	2010052818	5.005	139.510	1007.4	26.8	84	92	5.0	5189	8	As
RS139	2010052821	5.001	139.513	1007.7	28.4	78	60	5.0	24078	10	Cs, Ac, Cu, Sc, Nb, Ns
RS140	2010052900	5.006	139.516	1009.7	26.1	87	67	6.4	5835	10	Ns
RS141	2010052903	4.992	139.500	1009.0	27.5	78	148	3.1	23426	10	Ns, Cu, Sc, As
RS142	2010052906	4.983	139.506	1007.5	26.5	90	201	0.7	22395	8	Ns, Cb, Cu
RS143	2010052909	4.985	139.513	1006.7	27.4	85	164	3.1	21775	10	As, Cu, Ac, Sc

RS144	2010052912	4.991	139.507	1008.6	27.6	78	315	0.1	24580	2	Cu,Sc,As
RS145	2010052915	4.999	139.511	1009.0	27.9	73	90	0.9	24377	4	Cu,Sc,As
RS146	2010052918	4.984	139.520	1007.6	27.8	77	349	0.2	25013	3	Cu,As
RS147	2010052921	5.017	139.495	1007.9	27.7	77	270	0.3	24658	2	Ci,Cu,Sc,Ac
RS148	2010053000	5.000	139.500	1009.3	28.7	74	58	1.3	25685	1	Ci,Ac,Cs,Cu
RS149	2010053003	5.001	139.507	1008.6	30.0	69	180	0.9	23666	4	Ci,As,Sc,Ac,Cu
RS150	2010053006	4.997	139.477	1006.6	30.1	65	267	0.2	23978	3	Cu, Sc, Ac, Ci
RS151	2010053009	4.990	139.491	1007.4	29.7	67	165	0.2	24554	5	Cu,As,Ac,Cb
RS152	2010053012	4.992	139.517	1008.5	29.3	68	55	2.9	5160	－	－
RS153	2010053015	5.013	139.509	1008.5	27.6	71	116	3.1	21171	10	Sc
RS154	2010053018	4.999	139.518	1006.4	27.8	81	83	2.8	24982	9	Cc,Cu,As,Sc
RS155	2010053021	5.016	139.516	1007.2	28.3	78	32	3.8	24518	6	Ac,As,Cc,Cu,Sc
RS156	2010053100	5.013	139.504	1008.7	28.7	75	47	4.4	25620	10	Sc, Cu, Ac
RS157	2010053103	4.990	139.508	1008.1	26.8	87	42	4.6	25200	9	Ns, Cu, Sc, Ci
RS158	2010053106	5.021	139.511	1005.7	29.7	70	60	4.5	25813	6	Cu, Ac, Cc, Sc
RS159	2010053109	5.000	139.512	1005.7	29.1	73	80	2.3	23844	4	Cu,As,Ac,Cc,Ci
RS160	2010053112	4.980	139.506	1007.1	28.9	75	105	1.6	24532	1	Sc
RS161	2010053115	4.987	139.503	1007.3	28.8	76	99	3.3	25595	6	Cu
RS162	2010053118	4.988	139.516	1006.1	28.6	73	62	5.1	24846	1	Cu,Sc
RS163	2010053121	5.002	139.515	1006.7	28.7	75	72	3.1	23527	6	Nb,As,Ac,Cu,Sc
RS164	2010060100	4.999	139.499	1007.6	29.2	70	99	4.2	24960	1	Cu,As
RS165	2010060103	4.994	139.512	1006.6	29.9	71	71	3.2	25339	1	Cu, Sc
RS166	2010060106	5.004	139.518	1004.9	30.8	65	49	2.3	24480	2	Cu, Cc, Ac
RS167	2010060109	5.006	139.513	1005.9	29.6	68	94	0.6	22475	7	Cu, Cb, As, Ci
RS168	2010060112	5.001	139.513	1007.7	28.2	80	98	2.2	25072	10	Sc
RS169	2010060115	5.001	139.511	1007.7	28.8	70	83	2.1	24574	1	Sc,Ac
RS170	2010060118	5.002	139.524	1006.7	28.8	73	77	2.1	26468	1	Cu,Sc
RS171	2010060121	5.003	139.519	1007.5	28.6	75	60	3.1	25779	5	Cu,Ci,Ac,As,Sc
RS172	2010060200	5.000	139.500	1009.0	28.9	75	65	3.8	25297	6	Cu,Ci,Ac,As,Nb
RS173	2010060203	5.012	139.505	1007.9	29.1	74	57	4.6	25904	7	Cu, Ci, Ac,Cc
RS174	2010060206	5.011	139.508	1006.5	29.2	72	78	4.5	24830	8	Cb, Cu, Sc, Ci
RS175	2010060209	5.001	139.516	1007.3	27.1	84	122	1.8	24224	5	As, Cb, Ns, Cu, Sc
RS176	2010060212	4.996	139.515	1009.4	27.9	79	70	1.6	24326	0	－
RS177	2010060215	5.006	139.512	1009.2	28.4	77	39	3.1	24090	7	Cu,Sc,Ac
RS178	2010060218	5.019	139.499	1007.5	28.6	76	47	1.9	25447	3	Ac,Cu,As
RS179	2010060221	5.010	139.501	1008.9	26.9	79	79	3.3	22717	10	Ns,Sc
RS180	2010060300	5.001	139.501	1009.7	27.4	81	114	2.1	22117	10	Ns,Cu,Sc,St
RS181	2010060303	5.017	139.501	1008.6	27.0	83	304	3.8	23820	9	Cu, Cb, Sc, As, Ns, Ci
RS182	2010060306	5.010	139.492	1006.9	26.9	88	357	1.9	23221	9	Cu, Sc, Ns, Ci
RS183	2010060309	5.014	139.496	1007.5	27.5	81	69	3.3	23552	9	As,Cb,Ns,Sc,Cu
RS184	2010060312	5.008	139.517	1008.9	28.3	77	70	4.9	24916	10	－
RS185	2010060315	4.999	139.513	1008.2	28.6	77	100	5.7	25211	10	Cu,Sc
RS186	2010060318	4.988	139.518	1007.2	28.7	78	104	7.0	25188	5	As,Cu
RS187	2010060321	4.991	139.511	1007.4	27.9	78	77	3.8	23192	7	Cb,Cu,Sc
RS188	2010060400	4.996	139.517	1008.9	27.5	81	77	3.2	20344	6	As,Cu,Sc
RS189	2010060403	5.000	139.513	1007.6	29.1	76	133	2.9	25111	3	Cu, Cc, Ac, Ci
RS190	2010060406	4.981	139.506	1006.3	30.0	72	116	4.0	24769	5	Cu
RS191	2010060409	4.989	139.513	1006.6	29.3	73	100	4.0	25555	3	Cu, Sc, Ns, Ci
RS192	2010060412	4.993	139.512	1008.1	29.1	76	106	3.0	24142	2	Cu,Sc

RS193	2010060415	4.999	139.516	1007.5	27.9	78	148	1.4	23388	3	Cu,Sc
RS194	2010060418	4.980	139.491	1006.2	28.5	78	51	0.3	25315	3	Sc,Cu
RS195	2010060421	5.003	139.518	1006.5	28.4	77	58	2.6	25218	5	Cu,Ci
RS196	2010060500	5.000	139.500	1007.8	29.2	72	65	4.3	23526	3	Cu,Sc,Cs
RS197	2010060503	5.007	139.513	1006.8	29.3	71	77	3.8	25281	4	Cu, Ci
RS198	2010060506	5.004	139.516	1005.1	30.3	70	82	5.1	24908	4	Cu, Ci
RS199	2010060509	4.999	139.515	1005.6	29.4	72	82	4.8	23894	7	Cu, Ci, Cc
RS200	2010060512	4.993	139.510	1007.3	29.2	74	90	4.3	24539	1	Cu
RS201	2010060515	4.993	139.513	1006.9	28.7	77	137	2.0	23649	2	Cu,Sc
RS202	2010060518	4.999	139.519	1006.0	29.1	73	114	1.8	23778	8	Cu,As,Sc
RS203	2010060521	4.992	139.513	1006.9	28.2	80	71	3.0	24441	9	As,Ac,Cu,Sc,Nb
RS204	2010060600	5.001	139.519	1008.1	29.2	74	51	2.7	21920	8	As,Ac,Cs,Cu,Sc
RS205	2010060603	5.000	139.518	1007.2	29.5	74	63	3.8	25129	8	Cu, As, Ac, Sc, Cc
RS206	2010060606	4.998	139.518	1006.2	28.4	74	65	0.9	24274	10	Cb, Cu, Sc
RS207	2010060609	4.998	139.515	1006.4	28.1	79	83	6.2	21551	10	As, Cu, Ns
RS208	2010060612	4.993	139.514	1007.7	28.0	77	88	4.9	25184	5	Cu,Sc
RS209	2010060615	4.992	139.513	1007.9	28.3	75	100	5.0	25186	10	Sc,Ns
RS210	2010060618	5.003	139.512	1006.3	27.2	79	56	6.8	15195	10	Ns,Sc
RS211	2010060621	5.005	139.514	1007.5	28.7	75	75	4.4	24640	9	Ns,Ac,Cu
RS212	2010060700	5.000	139.500	1008.9	27.3	82	101	4.1	24111	10	Ac,As,Cu,Sc
RS213	2010060703	5.000	139.511	1007.2	27.9	80	70	1.9	25289	9	Ac, As, Cu, Sc, Ns
RS214	2010060706	4.983	139.495	1005.0	29.3	73	205	6.9	24310	9	As, Cu, Ns, Sc
RS215	2010060709	4.986	139.491	1006.7	29.0	74	185	4.9	25028	5	Cu, Ac, Sc, Cc
RS216	2010060712	5.011	139.503	1008.5	29.0	74	169	3.9	25493	9	Sc
RS217	2010060715	4.987	139.498	1008.1	28.5	75	189	3.1	24724	2	Sc
RS218	2010060718	4.981	139.491	1006.6	28.9	71	181	3.2	22643	6	Cu,Sc,Ac
RS219	2010060721	4.984	139.497	1007.0	28.6	74	151	2.3	24583	10	Ac,As,Cu,Sc
RS220	2010060800	4.999	139.500	1008.7	28.9	74	159	2.1	24843	9	Ac,Cu,Sc
RS221	2010060803	4.985	139.508	1007.3	30.1	68	102	2.0	25467	7	As, Cc, Cs, Sc, Cu
RS222	2010060806	4.987	139.509	1005.6	29.9	67	76	2.8	25032	4	Cs, Cc, Ci, Ac, Sc, Cu
RS223	2010060809	5.001	139.510	1006.2	29.2	71	62	3.0	23317	4	Ci, Cs, Cu, Sc
RS224	2010060812	4.996	139.510	1008.0	29.1	70	86	4.6	24556	3	Sc,Ac
RS225	2010060815	4.990	139.510	1007.8	29.0	69	112	4.2	24273	3	Cu,Sc
RS226	2010060818	4.981	139.509	1006.3	28.9	73	119	3.4	24273	6	Sc
RS227	2010060821	4.996	139.510	1006.9	28.1	74	58	2.6	24610	3	Ci,Cu,Sc
RS228	2010060900	5.000	139.499	1007.9	29.4	72	92	5.2	23555	5	Cb,Cu,Ac,As
RS229	2010060903	5.000	139.512	1006.7	29.5	71	77	3.8	25462	1	Cu, Ci
RS230	2010060906	5.000	139.499	1005.2	29.2	75	86	2.4	25769	1	Cu, As
RS231	2010060909	5.001	139.513	1005.8	29.7	71	96	2.5	23698	9	Cu, Ci
RS232	2010060912	4.970	139.521	1008.7	27.3	77	135	2.8	24192	3	Cu,Sc
RS233	2010060915	4.997	139.511	1009.2	25.7	86	114	7.7	18673	10	Ns
RS234	2010060918	5.007	139.485	1007.9	26.5	82	228	1.7	23666	7	Sc
RS235	2010060921	4.999	139.485	1007.9	27.4	78	57	1.1	23980	9	Ac,Cu,Sc
RS236	2010061000	5.014	139.499	1009.1	27.3	76	53	3.7	25068	3	Ac,Sc,Cu
RS237	2010061003	5.007	139.503	1008.5	29.1	76	57	5.2	25068	6	Nb,Cu,Ac,As,Cc,Ci
RS238	2010061006	5.003	139.513	1006.6	29.5	73	58	8.6	25429	6	Cu,Cb,As
RS239	2010061009	5.003	139.510	1006.5	29.0	72	65	5.6	23919	3	Cu,Ci
RS240	2010061012	4.999	139.509	1008.0	28.9	72	82	6.1	22985	1	As
RS241	2010061015	5.000	139.511	1007.9	28.9	75	90	4.7	24770	1	Cu,As

RS242	2010061018	4.998	139.516	1006.9	28.8	76	61	4.4	25097	1	As,Sc
RS243	2010061021	5.004	139.509	1007.8	28.8	73	90	6.7	24202	2	Ci, Cu
RS244	2010061100	4.999	139.499	1009.0	29.5	72	83	5.9	25674	1	Cu, Ci
RS245	2010061103	5.001	139.512	1008.0	29.7	68	84	6.0	25215	2	Cu, Ci
RS246	2010061106	5.003	139.518	1006.2	29.9	67	80	4.8	25681	3	Cu,As,Ci
RS247	2010061109	5.001	139.514	1007.1	29.5	68	84	5.1	24230	3	Cu, Ci
RS248	2010061112	4.995	139.515	1009.0	29.3	72	92	3.9	25065	0	–
RS249	2010061115	4.996	139.518	1009.0	29.1	73	77	4.3	25036	2	–
RS250	2010061118	5.006	139.516	1007.2	29.1	72	89	3.6	25402	1	Sc
RS251	2010061121	5.001	139.515	1007.5	28.8	74	65	4.8	24864	3	Cu, Ci
RS252	2010061200	5.010	139.511	1008.6	29.6	66	82	5.2	24798	8	Cu, Cb, Cc, Ci
RS253	2010061203	5.008	139.513	1008.1	28.6	77	61	4.3	24408	10	Sc,Cu,Ns
RS254	2010061206	5.003	139.503	1006.0	29.0	72	72	5.4	23417	9	Cu,Sc,Ac
RS255	2010061209	4.996	139.516	1006.9	28.3	76	147	2.6	21910	10	Cu,As,Cb
RS256	2010061212	4.989	139.507	1008.2	28.6	78	57	3.0	23589	10	Ns
RS257	2010061215	4.999	139.524	1008.1	28.6	79	74	4.2	22608	5	Ns
RS258	2010061218	5.008	139.516	1006.4	28.9	75	80	5.1	24631	1	–
RS259	2010061221	5.007	139.510	1007.4	28.6	73	108	5.1	23218	9	Cb, Cu
RS260	2010061300	5.000	139.499	1008.5	28.9	75	69	2.7	25878	8	Cu, Ci
RS261	2010061303	5.004	139.514	1007.5	29.9	68	67	6.0	25647	4	Cu,Cb,As,Cs
RS262	2010061306	5.016	139.513	1006.0	29.5	69	63	6.9	25032	6	Cu,As,Sc,Ac
RS263	2010061309	5.010	139.512	1006.5	29.5	69	83	5.7	24558	8	Cu,Sc,Ac,Ci
RS264	2010061312	4.999	139.514	1008.5	29.3	76	70	4.8	23721	3	–
RS265	2010061315	5.000	139.527	1008.5	29.2	74	85	4.8	24463	4	–
RS266	2010061318	4.990	139.507	1007.7	28.3	75	90	3.0	25283	1	–
RS267	2010061321	4.990	139.514	1007.8	28.3	79	109	1.5	23876	3	Cu, Sc, Ci
RS268	2010061400	4.999	139.500	1008.8	29.0	76	124	3.0	24816	1	Cu, Ci, As
RS269	2010061403	4.983	139.510	1008.1	29.7	71	143	3.6	23965	3	Cu,Cg,Sc,As,Ac
RS270	2010061406	4.978	139.511	1006.3	29.9	69	138	1.3	25171	5	Cu,Sc,As
RS271	2010061409	4.996	139.515	1006.6	28.3	81	81	6.7	22427	9	As,Cu,Sc
RS272	2010061412	5.001	139.520	1008.4	27.9	78	126	3.5	24704	10	–
RS273	2010061415	4.985	139.513	1008.3	28.4	73	66	3.1	23676	1	–
RS274	2010061418	5.010	139.519	1007.6	28.3	74	101	2.5	25594	1	As
RS275	2010061421	4.997	139.519	1007.2	28.2	78	89	1.8	25295	5	Cu, Ac, Cc, Ci
RS276	2010061500	5.000	139.500	1008.3	28.9	74	55	2.9	22851	5	Cu, St, Ci, Cc
RS277	2010061503	5.012	139.512	1007.6	28.9	70	38	3.5	25066	6	Cu,Ac,As,Sc,Cb
RS278	2010061506	5.014	139.507	1007.2	26.3	88	96	8.1	6130	10	Cu,Ns,Sc
RS279	2010061509	4.987	139.511	1006.9	24.9	86	29	5.5	20929	10	Ns,Sc
RS280	2010061512	4.985	139.526	1006.2	27.2	79	196	1.8	23751	9	Ns,Sc
RS281	2010061515	4.986	139.508	1007.7	28.5	71	78	7.0	22988	5	Sc,Ns
RS282	2010061518	5.005	139.519	1006.4	29.2	67	85	6.5	24959	1	As
RS283	2010061521	5.001	139.509	1006.4	29.0	70	86	6.0	23622	4	Cu, Ac, Ci, St
RS284	2010061600	5.005	139.513	1007.7	29.2	74	85	5.2	24796	1	Cu, Cc, Ci, Ac
RS285	2010061603	5.000	139.508	1007.1	29.3	72	100	5.2	25605	2	Cu,Sc,As,Ci
RS286	2010061606	4.990	139.513	1005.6	29.3	72	93	4.8	25445	3	Cu,As,Sc,Cc
RS287	2010061609	4.993	139.511	1005.9	29.4	73	107	4.7	24078	3	Cu,Sc,Ci
RS288	2010061612	4.998	139.510	1007.4	28.6	74	76	3.4	24318	1	Sc,Cu
RS289	2010061615	5.001	139.527	1007.1	29.3	72	101	4.7	24433	0	–
RS290	2010061618	4.991	139.518	1006.2	29.0	74	91	5.3	24883	2	As,Sc,Cu

RS291	2010061621	5.001	139.516	1006.8	28.9	73	93	4.7	23363	3	Cu, Ci
RS292	2010061700	5.001	139.500	1008.3	29.6	69	84	4.3	25561	6	Cb, Cu, Cc, Ci
RS293	2010061703	5.009	139.512	1007.5	27.8	80	340	2.5	24879	4	Cu,Sc,As,Ac,Cb
RS294	2010061706	5.014	139.512	1006.6	26.6	78	111	3.0	24833	8	Cu,As,Ac,Ns
RS295	2010061709	5.002	139.511	1006.3	28.6	75	54	6.4	24852	2	Ci,Cb,Cc,Cu
RS296	2010061712	5.003	139.509	1008.4	28.8	75	93	4.6	24756	2	As,Ac,Cu,Sc
RS297	2010061715	5.003	139.517	1008.3	28.7	74	99	3.8	24901	1	Cu,As
RS298	2010061718	5.006	139.518	1007.4	28.3	76	76	0.7	24812	2	As,Sc,Cu
RS299	2010061721	5.003	139.516	1007.4	28.7	72	82	4.1	25319	8	Cb, Cu, Ci, St
RS300	2010061800	5.004	139.517	1008.1	28.9	72	74	3.6	24793	9	Cu, Cs, Ci
RS301	2010061803	5.005	139.518	1007.2	29.0	73	66	4.8	25980	7	Cu,Sc,Ns,As,Ac
RS302	2010061806	5.011	139.515	1005.6	29.2	73	67	3.7	24651	7	Cu,Sc,As,Ac
RS303	2010061809	5.006	139.518	1006.4	29.2	74	84	2.6	23312	5	Ci,Cu,As,Cs
RS304	2010061812	4.999	139.522	1007.9	29.2	76	84	4.3	24764	6	Cu,As,Ac,Sc
RS305	2010061815	4.998	139.519	1007.8	28.1	75	56	9.3	24368	8	Cu,As
RS306	2010061818	5.007	139.512	1007.0	27.4	78	94	7.8	25568	4	As,Cu,Sc
RS307	2010061821	5.006	139.513	1007.4	28.2	72	87	5.6	24339	8	Cu, St, Ac, As
RS308	2010061900	5.000	139.498	1009.3	28.6	75	114	5.3	24834	10	Cb, Cu
RS309	2010061903	4.987	139.507	1007.1	27.8	76	147	8.3	25571	9	Cu,Sc,As
RS310	2010061906	4.976	139.498	1005.0	28.7	69	125	4.5	25030	10	Cu,Sc,As,Ac
RS311	2010061909	4.992	139.511	1006.2	28.6	72	103	4.1	23062	10	As,Cu,Sc
RS312	2010061912	4.999	139.519	1007.4	28.6	73	81	2.2	23805	10	As,Cu,Sc
RS313	2010061915	5.004	139.514	1007.1	26.0	84	65	6.6	22393	10	Ns
RS314	2010061918	5.017	139.508	1005.4	27.7	79	55	6.4	22521	10	Ns
RS315	2010061921	5.010	139.511	1006.1	28.1	78	43	5.3	23831	9	Cu, As, Sc
RS316	2010062000	5.001	139.500	1007.9	29.2	72	54	6.6	26089	3	Cu, As
RS317	2010062003	5.018	139.495	1006.9	28.9	74	82	9.0	25389	10	Cu,Cb,Sc
RS318	2010062006	5.001	139.516	1006.4	26.4	77	121	9.0	22279	10	Cu,Sc
RS319	2010062009	4.984	139.503	1007.3	26.9	81	134	4.6	20784	10	As,Sc
RS320	2010062012	4.988	139.515	1008.4	28.3	75	161	2.6	22917	10	As,Sc
RS321	2010062015	5.001	139.148	1007.8	27.2	79	153	4.8	22943	10	As,Sc
RS322	2010062018	5.013	138.381	1004.9	28.1	73	118	4.4	23138	8	As, Sc
RS323	2010062021	5.000	138.144	1006.2	28.5	76	91	7.6	24633	4	Ac, Cu
RS324	2010062100	5.000	138.750	1008.6	29.5	66	92	6.8	25727	3	Cu, Ac
RS325	2010062103	4.998	139.361	1007.1	29.2	72	77	7.1	25594	4	Cu,Sc,As,Ac,Ci
RS326	2010062106	5.014	139.878	1005.2	29.4	71	86	8.0	25911	3	Cu,As,Ac,Ci
RS327	2010062109	5.004	140.418	1006.7	29.3	71	76	7.4	23156	3	Cu,Ci,Cb
RS328	2010062112	5.000	141.000	1008.5	29.2	71	71	8.7	23600	3	As,Cu
RS329	2010062115	4.569	140.566	1007.7	27.4	78	82	3.9	22012	8	As,Cu,Sc
RS330	2010062118	4.031	140.023	1006.9	28.1	74	96	4.2	23777	4	As,Sc,Cu
RS331	2010062121	3.568	139.566	1007.5	28.4	76	80	7.4	24826	9	St, Cu, Ac
RS332	2010062200	3.911	139.499	1009.0	28.8	77	69	7.0	24466	5	Cu, As, Cc
RS333	2010062203	4.394	139.499	1007.5	29.3	73	62	3.8	25155	8	Cu,Cb,Sc,As,Ac
RS334	2010062206	5.000	139.500	1006.2	29.6	72	36	5.1	24974	2	Cu,Sc,As,Cc
RS335	2010062209	5.652	139.502	1007.1	29.3	72	42	4.1	24277	2	Cu,Ac,As
RS336	2010062212	6.136	139.500	1009.0	26.1	85	49	0.8	18861	10	Ac,As,Sc,Cu
RS337	2010062215	6.636	139.498	1007.9	27.3	77	273	3.2	21249	6	Cu,As,Ns
RS338	2010062218	7.359	139.496	1006.4	26.2	88	338	2.9	24720	4	Cu,Sc,As,Ns
RS339	2010062221	7.999	139.499	1006.8	28.3	78	49	6.3	24601	4	Cu, Ac

RS340	2010062300	8.597	139.345	1008.1	29.3	71	83	6.3	25263	4	Cb, Cu, As, Cc
RS341	2010062303	9.364	139.134	1006.7	27.8	76	103	4.8	24515	6	Cb,Cu,As
RS342	2010062306	9.925	138.957	1006.1	28.1	81	132	11.4	25058	9	Cu,Cb,Sc,Ns
RS343	2010062309	10.638	138.764	1006.4	26.9	84	211	4.2	22540	9	Ns,Cu,As
RS344	2010062312	11.375	138.602	1007.9	27.4	84	191	10.6	22582	6	As,Cu,Sc
RS345	2010062315	12.141	138.388	1007.0	27.8	72	136	3.1	24511	5	As,Ac,Cu
RS346	2010062318	12.871	138.192	1005.8	28.1	80	145	5.4	22858	4	Cu,Ci
RS347	2010062321	13.607	138.011	1006.3	28.5	72	135	5.9	25402	2	Cu,Cb
RS348	2010062400	14.332	137.787	1006.6	29.1	72	157	6.4	18722	2	Cu, Ci
RS349	2010062406	15.835	137.386	1005.4	29.2	73	98	4.1	23377	5	Cu,Cb,Sc,As
RS350	2010062412	17.124	136.853	1006.7	27.0	79	138	8.8	23561	3	Cu,Ac,As,Cb
RS351	2010062418	18.593	136.650	1006.9	27.0	75	92	8.9	24882	6	Ns,As,Cu,Sc
RS352	2010062500	19.996	136.200	1009.0	28.8	75	124	8.8	25322	4	Cc, Cu, Ac
RS353	2010062506	21.331	135.750	1008.2	29.2	70	133	8.5	25308	4	Cu,Cb,As,Cc,Ci
RS354	2010062512	22.800	135.209	1010.1	29.0	72	124	7.2	25147	2	Cu,As
RS355	2010062518	24.224	134.681	1010.9	27.6	82	124	6.7	25361	3	As,Ac,Sc,Cu,Cb
RS356	2010062600	25.678	134.134	1012.0	27.8	81	143	8.8	27127	1	Cu,As,Ci,Cc
RS357	2010062606	27.156	133.604	1011.9	27.8	84	150	7.2	25312	4	Ci, Cu
RS358	2010062612	28.552	133.061	1013.8	26.9	90	174	6.5	24829	1	Ci
RS359	2010062618	29.996	132.513	1012.0	26.5	91	199	8.5	20960	10	As,Sc
RS360	2010062700	31.563	132.131	1011.6	26.7	88	204	8.7	23546	3	As,Ac,St

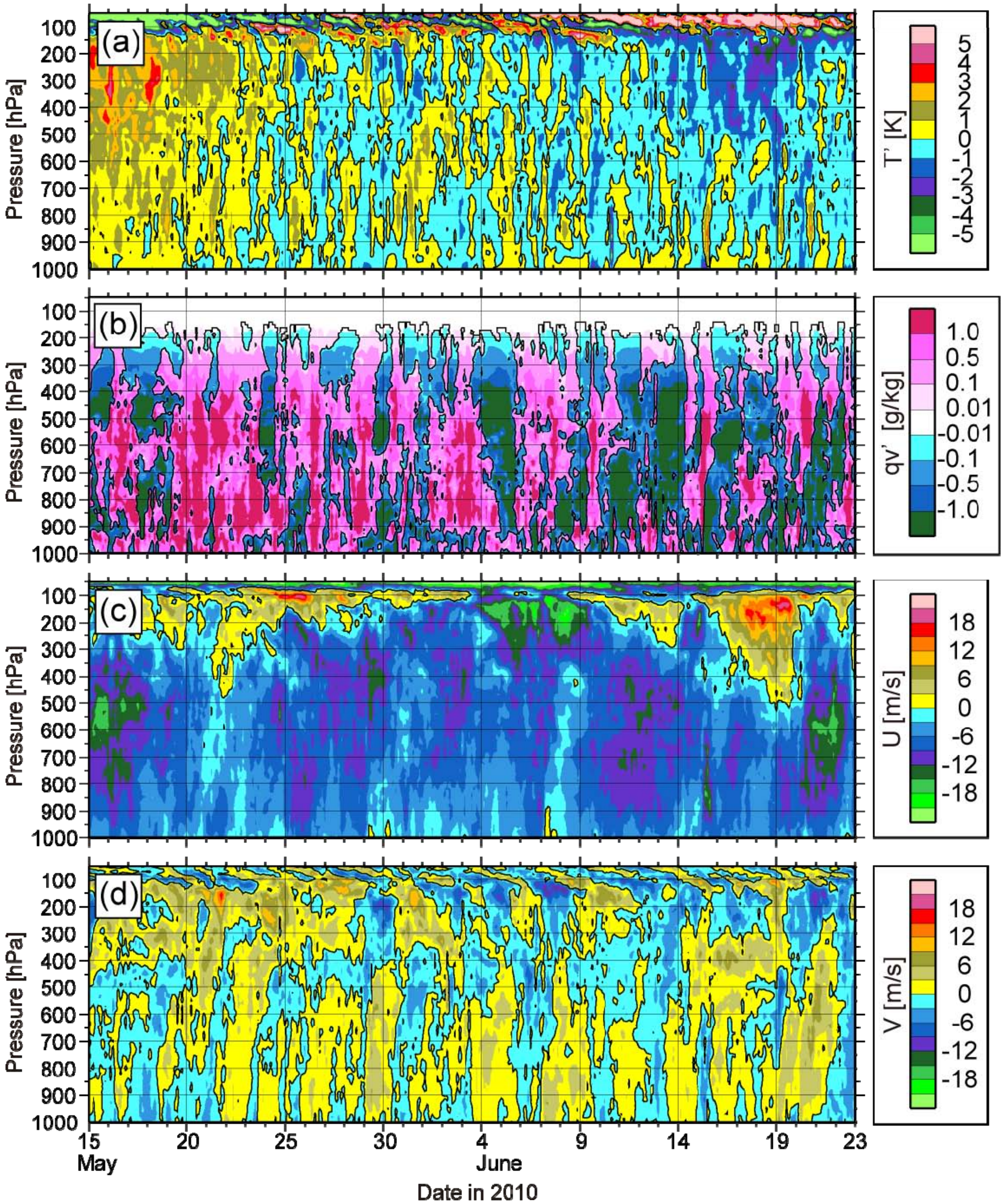


Fig.5.1-1: Time-height cross sections of (a) temperature, in anomaly to the period-averaged value at each pressure level, (b) water vapor mixing ratio, in anomaly to the period-averaged value at each pressure level, (c) zonal wind (absolute value), and (d) meridional wind (absolute value).

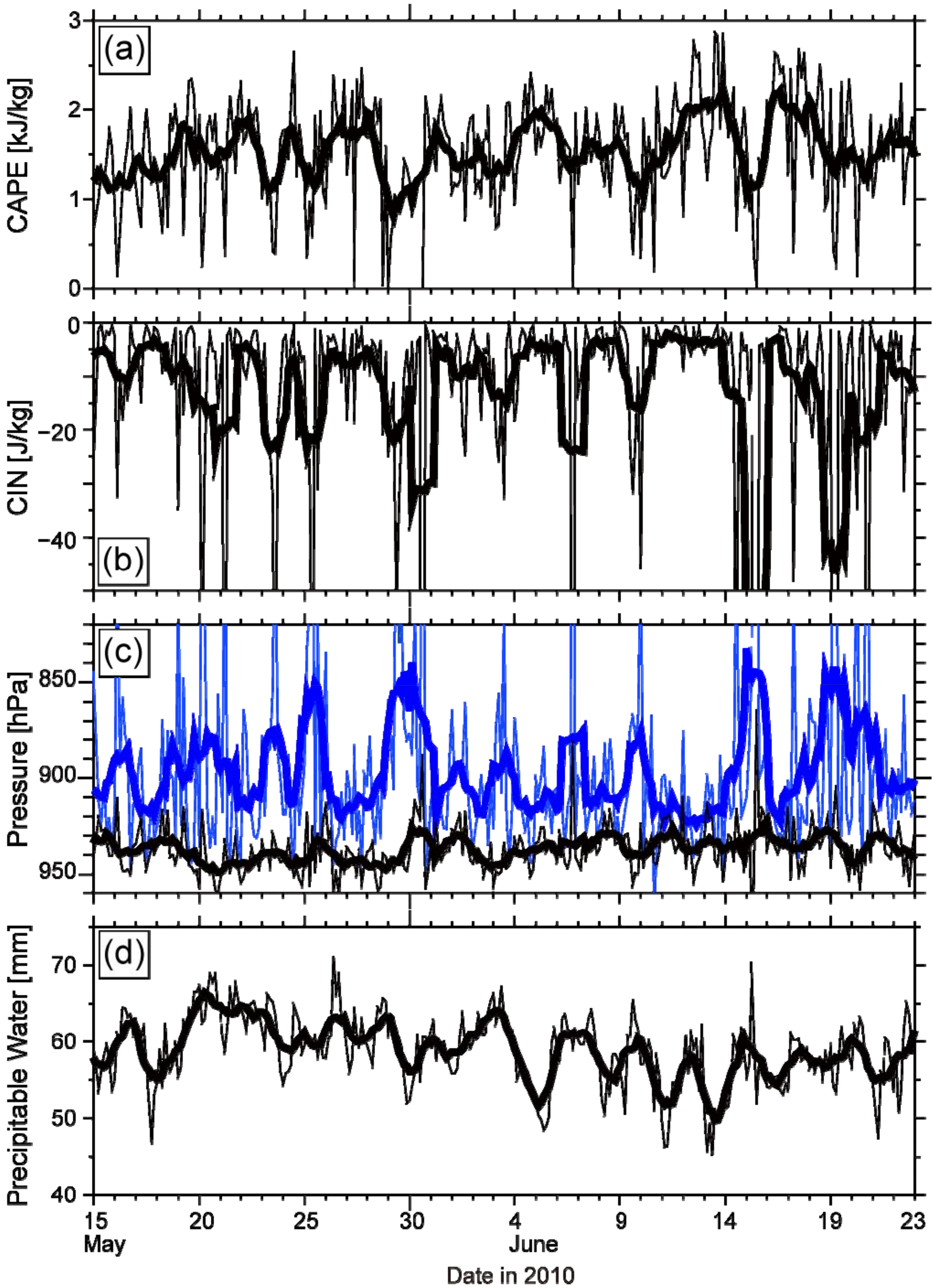


Fig.5.1-2: Time series of the parameters derived from the radiosonde observations; (a) CAPE, (b) CIN, (c) LCL (black) and LFC (blue), and (d) precipitable water. The thin lines are from the 3-hourly snapshots, while the thick lines are the running mean for 25 hours.

5.2 Doppler Radar

(1) Personnel

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Masaki KATSUMATA	(JAMSTEC)	
Hiroyuki YAMADA	(JAMSTEC)	
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Ryuji YOSHIDA	(Kyoto Univ.)	
Tetsuya TAKEMI	(Kyoto Univ.)	*not on board
Satoki TSUJINO	(Nagoya Univ.)	
Hiroshi UYEDA	(Nagoya Univ.)	
Taro SHINODA	(Nagoya Univ.)	*not on board
Souichiro SUEYOSHI	(GODI)	*Operation Leader
Harumi OTA	(GODI)	
Asuka DOI	(GODI)	
Ryo OHYAMA	(Mirai Crew)	

(2) Objective

The objective of the Doppler radar observation in this cruise is to investigate three dimensional rainfall and kinematic structures of precipitation systems and their temporal and special variations around the Western Pacific Ocean.

(3) Method

The Doppler radar on board of Mirai is used. The specification of the radar is:

Frequency:	5290 MHz
Beam Width:	less than 1.5 degrees
Output Power:	250 kW (Peak Power)
Signal Processor:	RVP-7 (Vaisala Inc. Sigmet Product Line, U.S.A.)
Inertial Navigation Unit:	PHINS (Ixsea S.A.S., France)
Application Software:	IRIS/Open (Vaisala Inc. Sigmet Product Line, U.S.A.)

Parameters of the radar are checked and calibrated at the beginning and the end of the intensive observation. Meanwhile, daily checking is performed for (1) frequency, (2) mean output power, (3) pulse width, and (4) PRF (pulse repetition frequency).

During the cruise, the volume scan consisting of 21 PPIs (Plan Position Indicator) is conducted every 10 minutes. A dual PRF mode with the maximum range of 160 km is used for the volume scan. Meanwhile, a surveillance PPI scan is performed every 30 minutes in a single PRF mode with the maximum range of 300 km. At the same time, RHI (Range Height Indicator) scans of the dual PRF mode are also operated whenever detailed vertical structures are necessary in certain azimuth directions. Detailed information for each observational mode is listed in Table 5.2-1. The Doppler radar observation is from May. 6 to May. 11, 2010 during the Leg 1, and from May. 13 to Jun. 26, 2010 during the Leg 2.

(4) Preliminary results

Figure 5.2-1 shows the time series of the ratio of radar echo area with respect to the radar coverage obtained from surveillance PPI scans during the stationary observation of Leg 2. Radar echo areas were larger from May 20 to May 29 and from Jun. 19 to Jun. 21, suggesting that convection were more active during these periods. Radar echo areas also showed distinct variations in small time interval. They peaked every 2-4 days, which would be related to the evolution of large scale disturbances around the intensive observational area. The time series of the daily frequency distribution of radar echo tops in the intensive observational area is shown in Fig. 5.2-2. Radar echo tops appeared more frequently in two layers. One was around altitudes of 3-5 km and the other was around altitudes of 6-9 km. This fact suggests that shallow cumulus and cumulus congestus were most prevalent precipitation systems in the intensive observational area.

Various kinds of precipitation systems have been observed by the Doppler radar. Figure 5.2-3 is an example which shows the horizontal distribution of radar echoes observed at 0559 UTC Jun. 20, 2010. Most of precipitation systems possessed linear structures and these linear precipitation systems were oriented both in southwest-northeast and southeast-northwester directions. Precipitation systems tended to develop into mesoscale convective systems (MCSs). By using the VAD method, Figure 5.2-4 shows a time-height section of radar echoes and earth-relative horizontal winds averaged over circular areas of ~100 km radius centered on the radar. This figure clearly shows the leading-convection/trailing-stratiform structures of a MCS. Convective echoes were observed in the front and these convective echoes were followed by stratiform echoes showing the radar bright band at about 5-km altitude. Figure 5.2-4 also indicates that the MCS developed in association with tropical easterly trade winds. Obviously, the internal rainfall and kinematic structures of precipitation systems evolved in the intensive observational area have been well observed by the Doppler radar.

(5) Data archive

All data of the Doppler radar observation during this cruise will be submitted to the JAMSTEC Data Integration and Analysis Group (DIAG).

Table 5.2-1 Parameters for each observational mode

	Surveillance PPI	Volume Scan	RHI
Pulse Width	2 (microsec)	0.5 (microsec)	0.5 (microsec)
Scan Speed	18 (deg/sec)	18 (deg/sec)	Automatically determined
PRF	260 (Hz)	900/720 (Hz)	900 (Hz)
Sweep Integration	32 samples	50 samples	32 samples
Ray Spacing	1.0 (deg)	1.0 (deg)	0.2 (deg)
Bin Spacing	250 (m)	250 (m)	250 (m)
Elevation Angle	0.5	0.5, 1.0, 1.8, 2.6, 3.4, 4.2, 5.0, 5.8, 6.7, 7.7, 8.9, 10.3, 12.3, 14.5, 17.1, 20.0, 23.3, 27.0, 31.0, 35.4, 40.0	0.0 to 45.0 or more
Azimuth	Full Circle	Full Circle	Optional
Range	300 (km)	160 (km)	160 (km)

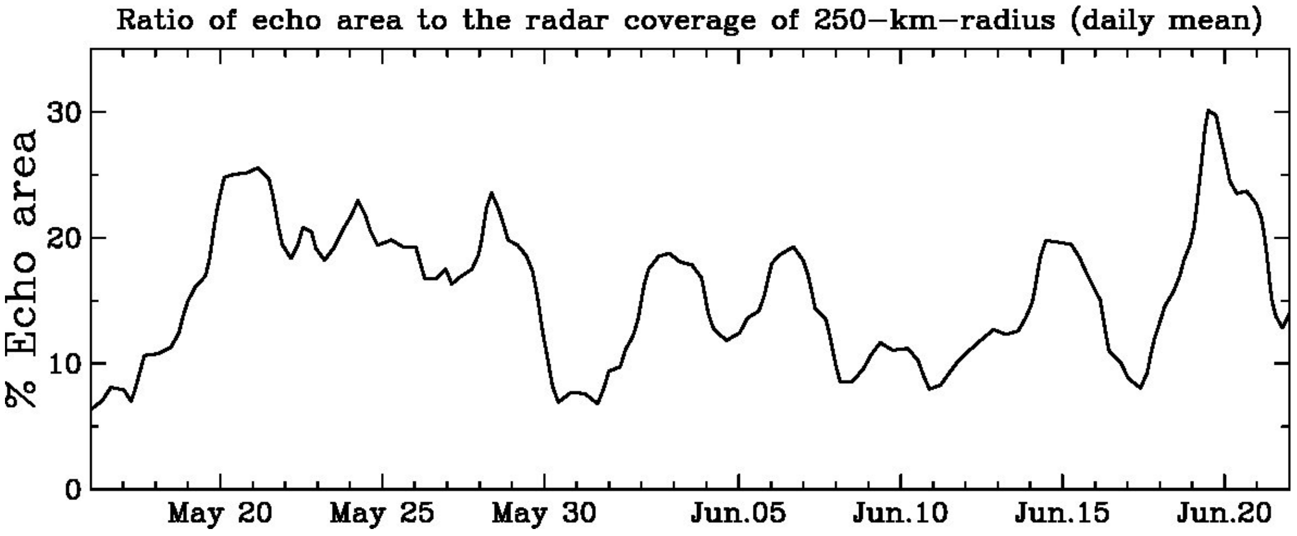

Fig. 5.2-1. Time series of the daily mean ratio of radar echo area with respect to the radar coverage obtained from surveillance PPI scans.

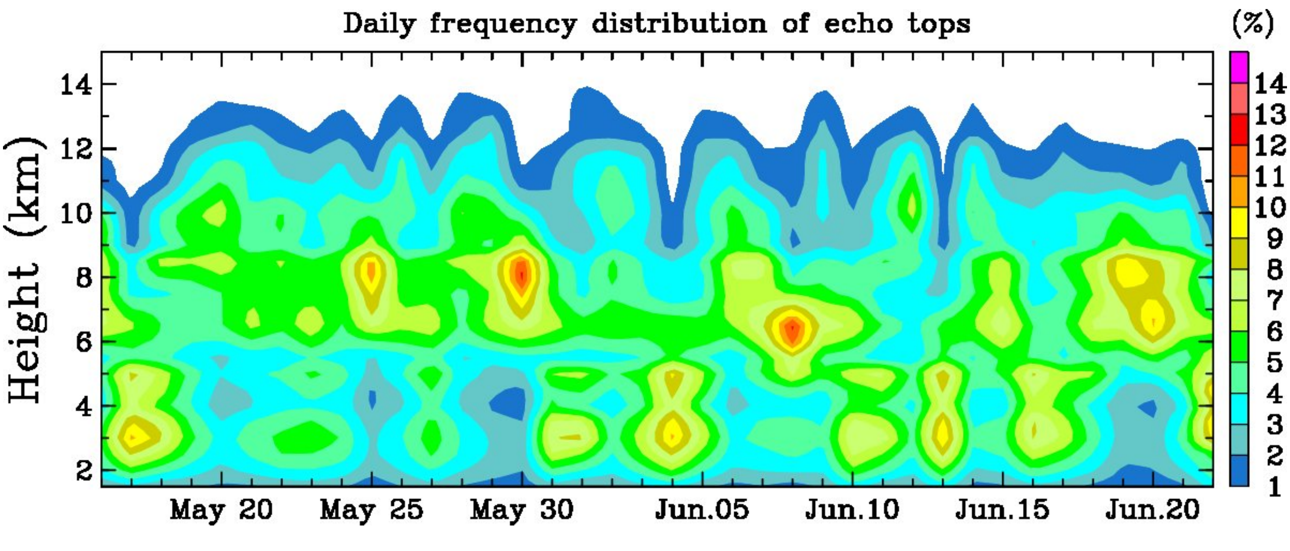

Fig. 5.2-2. Time series of the daily frequency distribution of radar echo tops.

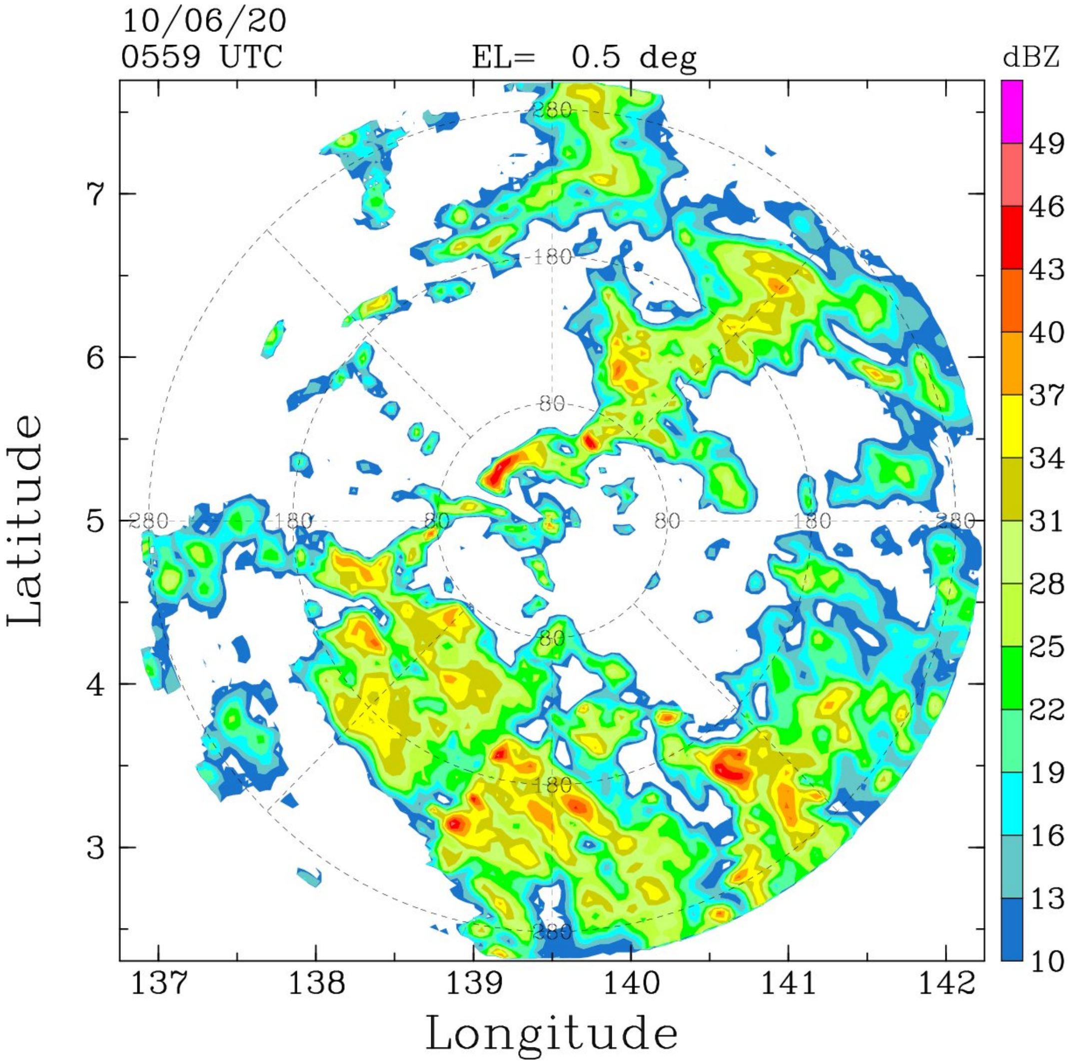

Fig. 5.2-3. Horizontal distribution of radar echoes obtained from the surveillance PPI scan at 0559 UTC Jun. 20, 2010.

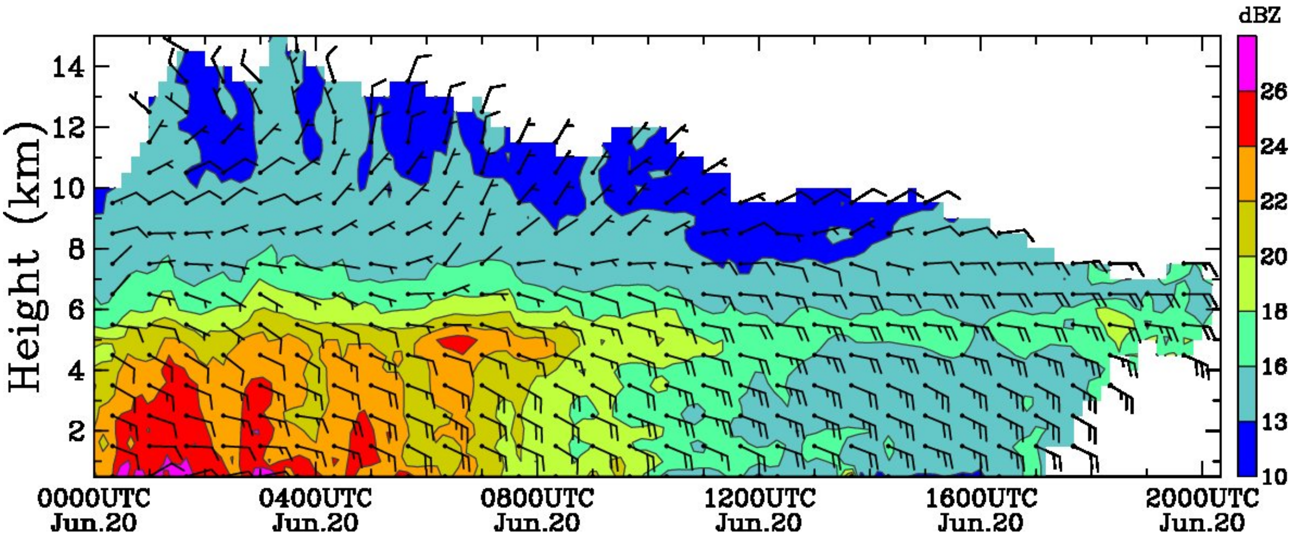

Fig. 5.2-4. Time-height section of radar echoes (shaded) and earth-relative horizontal wind (half barb = 2.5 m s^{-1} and full barb = 5 m s^{-1}) derived from the VAD method and averaged over circular areas of ~100 km radius centered on the radar.

5.3 95-GHz Cloud Profiling Radar

(1) Personnel

Toshiaki TAKANO (Chiba University): Principal Investigator
Shusuke MORIYA (Chiba University)
Shinji NAKAYAMA (Chiba University)
Daichi NISHINO (Chiba University) *not on board

(2) Objective

Main objective for the 95GHz cloud radar named FALCON-I is to detect vertical structure of cloud and precipitation and Doppler spectra of the observed targets. Combinational use of the radar, lidar, and infrared radiometer is recognized to be a powerful tool to study vertical distribution of cloud microphysics, i.e., particle size and liquid/ice water content (LWC/IWC).

(3) Methods

Observation with FALCON-I was done continuously with 15 sec repetition cycle for cloud profile. Basic output from data is cloud occurrence, radar reflectivity factor, and Doppler spectra. Sensitivity of FALCON-I is about -32 dBZ and its spacial resolution is about 15m at 5 km height. Doppler spectra are produced every 1 min.

In order to derive reliable cloud amount and cloud occurrence, we need to have radar and lidar for the same record. Radar / lidar retrieval algorithm has been developed in Tohoku University. The algorithm is applied to water cloud in low level and also cirrus cloud in high altitude. In order to analyze the radar data, it is first necessary to calibrate the signal to convert the received power to radar reflectivity factor, which is proportional to backscattering coefficient in the frequency of interest. Then we can interpolate radar and lidar data to match the same time and vertical resolution. Finally we can apply radar/lidar algorithm to infer cloud microphysics.

(4) Preliminary Results

The cloud radar is successfully operated for 24 hours during the cruise MR10-03 Leg1 and Leg2. The obtained data will be corrected and analyzed after the cruise.

(5) Data archive

The data archive server will be set inside Chiba University and the original data and the results of the analyses will be available from us.

5.4 Lidar Observations of Clouds and Aerosols

(1) Personnel

Nobuo SUGIMOTO (National Institute for Environmental Studies; NIES) * not on board

Ichiro MATSUI	(NIES)	* not on board
Atsushi SHIMIZU	(NIES)	* not on board
Tomoaki NISHIZAWA	(NIES)	* not on board
Souichiro SUEYOSHI	(GODI)	support for operation
Harumi OTA	(GODI)	support for operation
Asuka DOI	(GODI)	support for operation

(2) Objectives

Objective of the observations in this cruise is to study distribution and optical characteristics of ice/water clouds and marine aerosols using a two-wavelength lidar.

(3) Measured parameters

- Vertical profiles of backscattering coefficient at 532 nm
- Vertical profiles of backscattering coefficient at 1064 nm
- Depolarization ratio at 532 nm

(4) Method

Vertical profiles of aerosols and clouds were measured with a two-wavelength lidar. The lidar employs a Nd:YAG laser as a light source which generates the fundamental output at 1064 nm and the second harmonic at 532 nm. Transmitted laser energy is typically 30 mJ per pulse at both of 1064 and 532 nm. The pulse repetition rate is 10 Hz. The receiver telescope has a diameter of 20 cm. The receiver has three detection channels to receive the lidar signals at 1064 nm and the parallel and perpendicular polarization components at 532 nm. An analog-mode avalanche photo diode (APD) is used as a detector for 1064 nm, and photomultiplier tubes (PMTs) are used for 532 nm. The detected signals are recorded with a transient recorder and stored on a hard disk with a computer. The lidar system was installed in the radiosonde container on the compass deck. The container has a glass window on the roof, and the lidar was operated continuously regardless of weather. Every 10 minutes vertical profiles of four channels (532 parallel, 532 perpendicular, 1064, 532 near range) are recorded.

(5) Results

Lidar raw data have not been collected by NIES researchers because this is unattended subject. So we show here only sample vertical profiles of backscattering intensity which was automatically generated onboard and transferred to NIES by e-mail. Figure 5.4.1 shows an atmospheric structure revealed by lidar on June 26, 2010. There was a cloud layer around 13 km. High depolarization ratio (perpendicular to parallel at 532 nm) indicates this layer is consist of non-spherical ice particles. Below the cloud, some structure of aerosol layers was evident. A typical aerosol mixing layer was located blow 500m, but weak aerosol signal was detected between 0.8 – 1.5 km. Similar profiles are obtained every 10 minutes, and three dimensional structure of atmospheric scatterers (clouds and aerosols) are revealed in whole troposphere.

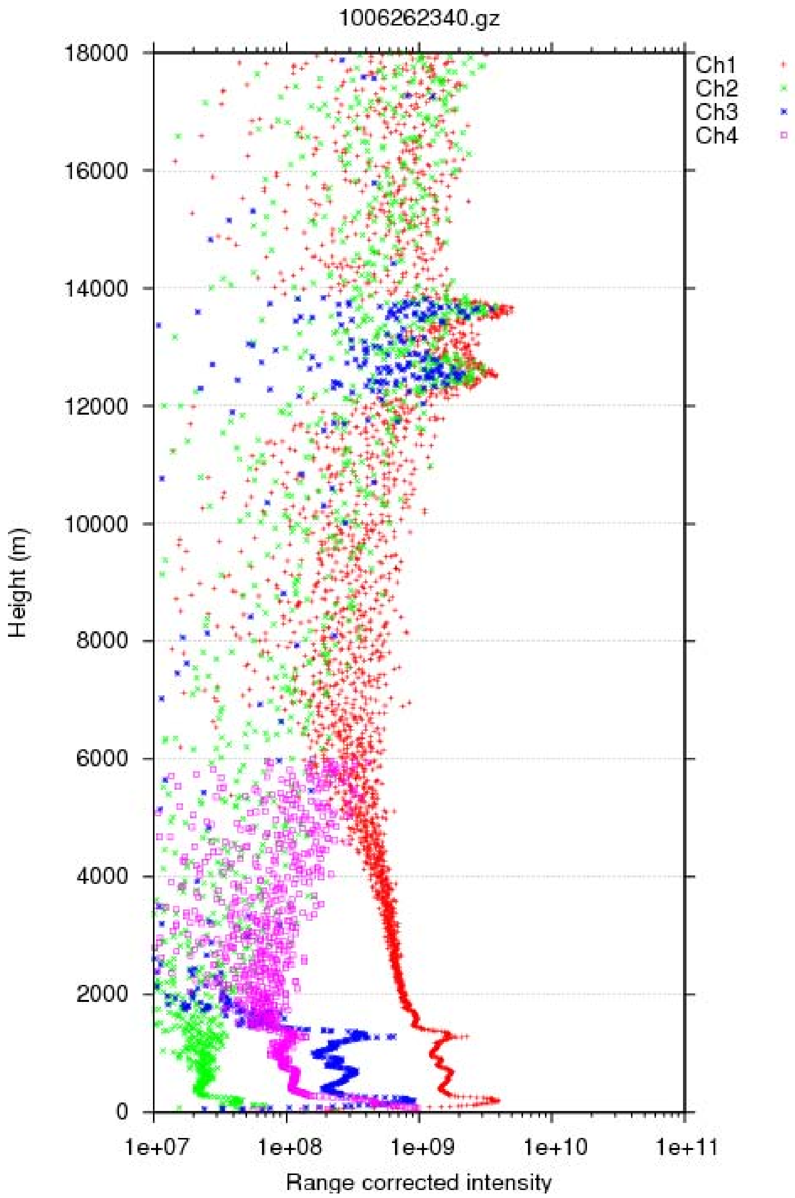

Figure 5.4.1: Vertical profiles of backscattering intensity at 532 nm parallel (red), 532 nm perpendicular (green), 1064 nm (blue) at UTC2340 on June 26, 2010. Pink indicates signal from near field telescope (532nm)

(6) Data archive

- raw data

    lidar signal at 532 nm

    lidar signal at 1064 nm

    depolarization ratio at 532 nm

    temporal resolution 15min/ vertical resolution 6 m

    data period (UTC) : 3:49 May. 6, 2010 - 23:00 May. 11, 2010,

    7:56 May. 13, 2010 – 22:30 Jun. 27, 2010

- processed data

    cloud base height, apparent cloud top height

    phase of clouds (ice/water)

    cloud fraction

    boundary layer height (aerosol layer upper boundary height)

    backscatter coefficient of aerosols

    particle depolarization ratio of aerosols

5.5 Ceilometer

(1) Personnel

Hiroyuki YAMADA	(JAMSTEC)	*Principal Investigator
Souichiro SUEYOSHI	(Global Ocean Development Inc., GODI)	
Harumi OTA	(GODI)	
Asuka DOI	(GODI)	
Ryo OHYAMA	(MIRAI Crew)	

(2) Objectives

The information of cloud base height and the liquid water amount around cloud base is important to understand the process on formation of the cloud. As one of the methods to measure them, the ceilometer observation was carried out.

(3) Methods

We measured cloud base height and backscatter profile using ceilometer (CT-25K, VAISALA, Finland) throughout the MR10-03 cruise. Major parameters for the measurement configuration are as follows;

Laser source:	Indium Gallium Arsenide (InGaAs) Diode
Transmitting center wavelength:	905±5 nm at 25 degC
Transmitting average power:	8.9 mW
Repetition rate:	5.57 kHz
Detector:	Silicon avalanche photodiode (APD)
	Responsibility at 905 nm: 65 A/W
Measurement range:	0 ~ 7.5 km
Resolution:	50 ft in full range
Sampling rate:	60 sec
Sky Condition	0, 1, 3, 5, 7, 8 oktas (9: Vertical Visibility)
	(0: Sky Clear, 1:Few, 3:Scattered, 5-7: Broken, 8: Overcast)

On the archive dataset, the following parameters are archived.

Cloud base height [m].

Backscatter profile, sensitivity and range normalized at 30 m resolution.

Estimated cloud amount [oktas] and height [m]; Sky Condition Algorithm.

The cloud base height and backscatter profile are recorded with the resolution of 30 m (100 ft).

(4) Preliminary results

Fig.5.5-1 shows the time series of the lowest, second and third cloud base height during the cruise.

(5) Data archives

The raw data obtained during this cruise will be submitted to the Data Integration and Analysis Group (DIAG) in JAMSTEC.

(6) Remarks

1) Following periods, data acquisition was suspended in the territorial waters.

04:00UTC 05th May 2010 to 06:40UTC 05th May 2010 (Guam, U.S.A.)

22:58UTC 11th May 2010 to 07:50UTC 13th May 2010 (Republic of Palau)

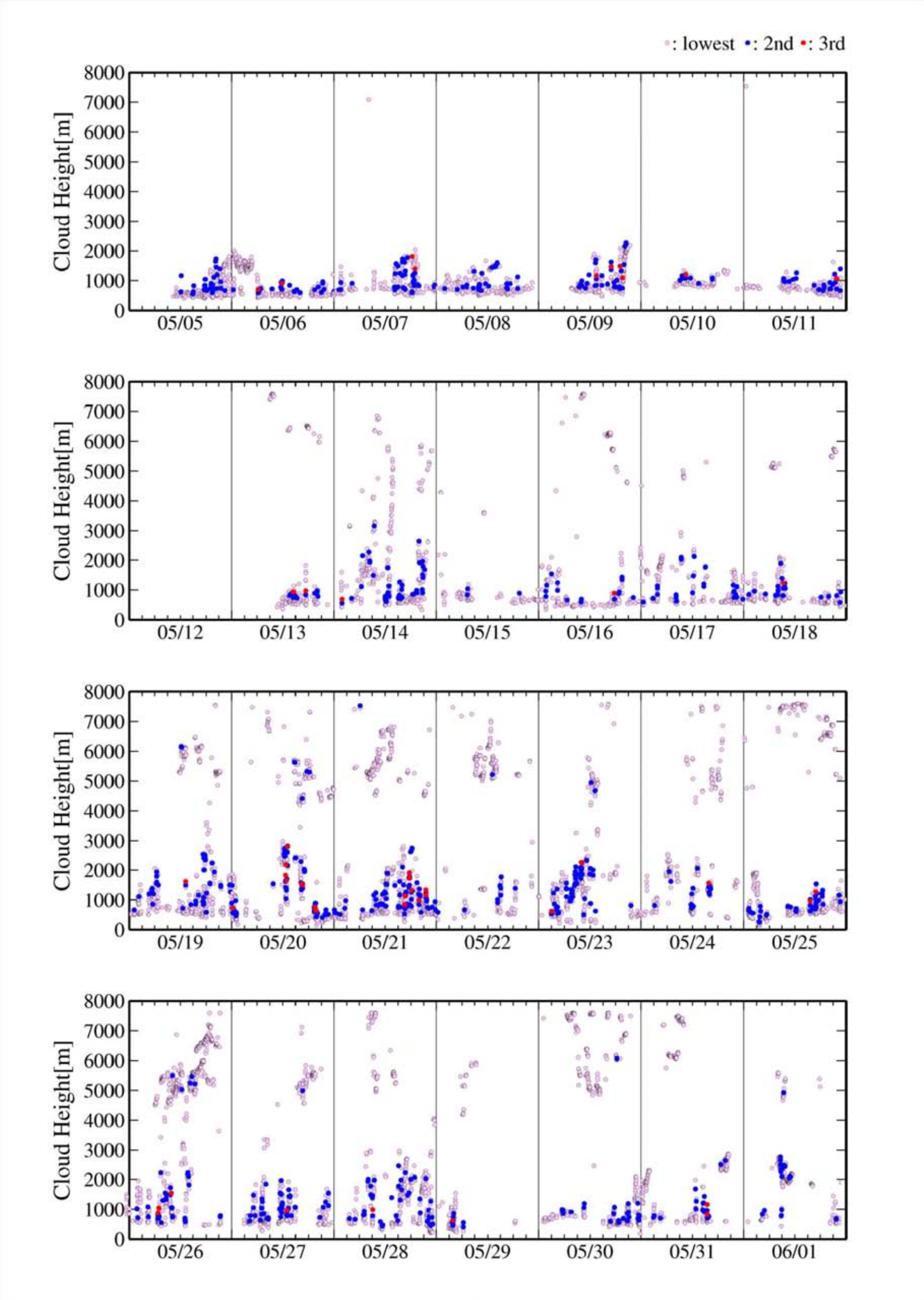

Fig. 5.5-1 *First, 2nd and 3rdlowest cloud base height during the cruise.*

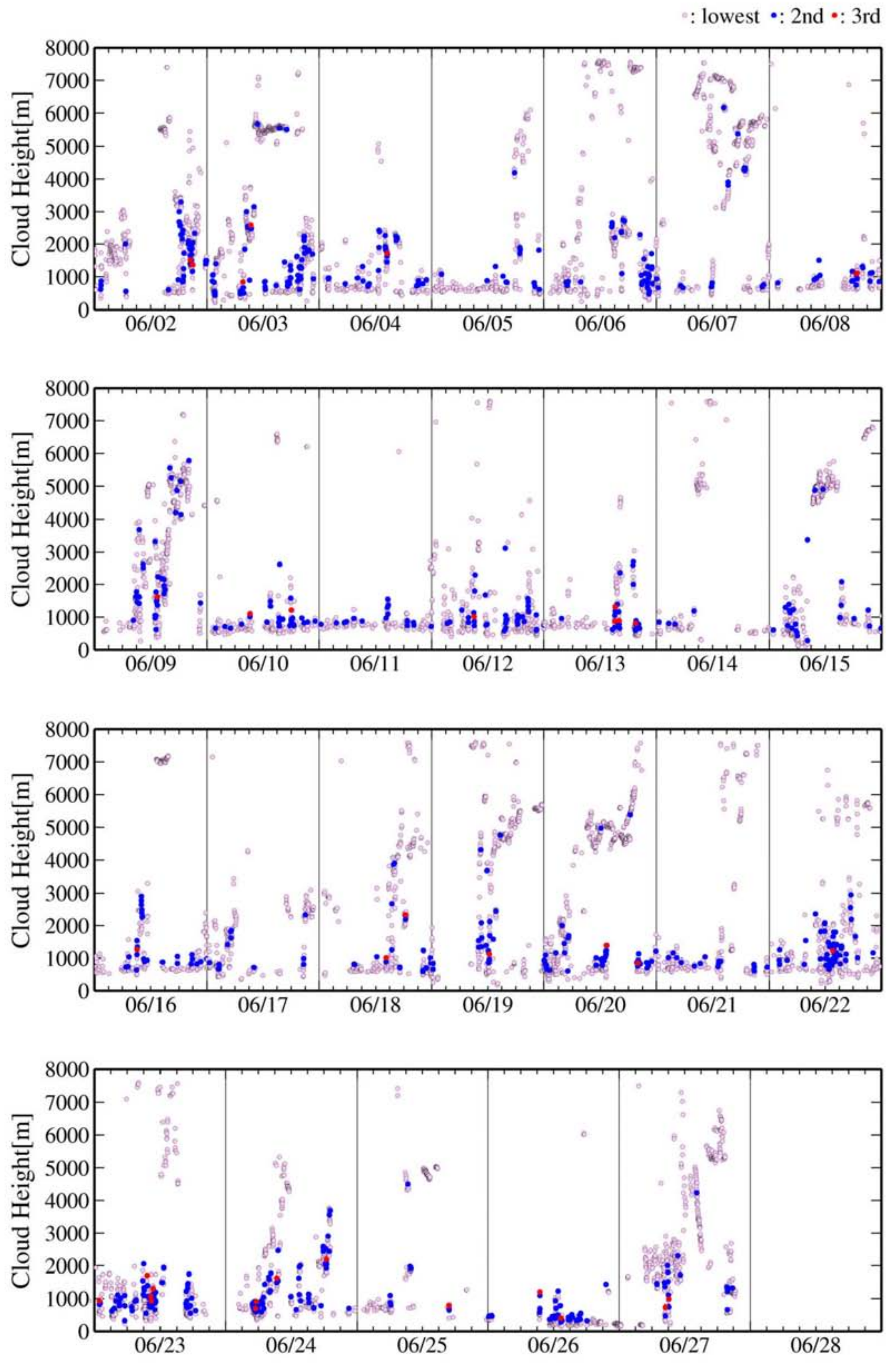

Fig. 5.5-1 *(Continued).*

5.6 GPS Meteorology

(1) Personnel

Mikiko Fujita	(JAMSTEC)	Principal Investigator	* not on board
Hiroyuki YAMADA	(JAMSTEC)		
Biao GENG	(JAMSTEC)		
Souichiro SUEYOSHI	(Global Ocean Development Inc., GODI)		Technical staff
Harumi OTA	(GODI)		Technical staff
Asuka DOI	(GODI)		Technical staff
Ryo OHYAMA	(MIRAI Crew)		Technical staff

(2) Objective

Getting the GPS and GLONASS satellite data to derived estimates of the total column integrated water vapor content of the atmosphere.

(3) Method

The GPS and GLONASS satellite data was archived to the receiver (Trimble NetR8) with 5 sec interval. The antenna (GNSS Choke Ring Antenna) was set on the deck at the part of stern. This observation was carried out from May 6 to June 28, 2010.

(4) Results

We will calculate the total column integrated water from observed satellite data later.

(5) Data archive

Raw data is recorded as RINEX format every 5 seconds during the observation. These raw datasets is available from M. Fujita of JAMSTEC.

5.7 Infrared radiometer

(1) Personnel

Hajime OKAMOTO (Kyushu University / Tohoku University): Principal Investigator * not on board
Toshiaki TAKANO (Chiba University)
Shusuke MORIYA (Chiba University)
Shinji NAKAYAMA (Chiba University)

(2) Objective

The infrared radiometer (hereafter IR) is used to derive the temperature of the cloud base and emissivity of the thin ice clouds. Main objectives are to study clouds and climate system in tropics by the combination of IR with active sensors such as lidar and 95GHz cloud radar with Doppler function. From these integrated approach, it is expected to extend our knowledge of clouds and climate system. We also improved a part of our instrument for the protection of precipitation.

Special emphasis is made to retrieve cloud microphysics in upper part of clouds, including sub-visual clouds that are recognized to be a key component for the exchange of water amount between troposphere and stratosphere. Since June 2006, spaceborn radar and lidar systems, CloudSat and CALIPSO are providing vertical and global distribution of clouds and aerosols. One important aim is to observe the same clouds and aerosols by the observational systems on R/V Mirai. Combination of space-based and ship based observations should provide the unique opportunity to study the complete system of theses clouds and aerosols in relation to its environments. These data will be also used to develop the retrieval algorithms for the new satellite mission, EarthCARE, that will currently be launched in 2013 and will carry Doppler CPR, high spectral resolution lidar, and imager.

(3) Method

IR instrument directly provides broadband infrared temperature (9.6-10.5μm).

General specifications of IR system (KT 19II, HEITRONICS)

Temperature range	-100 to 100^{o}C
Accuracy	0.5 ^{o}C
Mode	24hours
Time resolution	1 min.
Field of view	Less than 1^{o} (will be estimated later)
Spectral region	9.6-10.5μm

This is converted to the broadband radiance around the wavelength region. This is further combined with the lidar and/or radar for the retrieval of cloud microphysics such as optical thickness at visible wavelength, effective particle size. The applicability of the retrieval technique of the synergetic use of radar/IR or lidar/IR is so far limited to ice clouds. It is also worth to mention that the water cloud bottom can be accurately detected by the instrument. The information is very useful to identify the existence of water particles in clouds. The microphysics of clouds from these techniques will be compared with other retrieval technique such as radar/lidar one or radar with multi-parameter.

When the rain is observed by the rain sensor installed in the IR observing system, the radiometer is automatically rotated and stops at the downward position in order to prevent from the rain drops attached on the lens surface.

(4) Preliminary Results

Basically the IRT is operated for 24 hours. The automatic rain protection system works very fine except for some periods where the rain-protection system worked in clear sky condition after the somewhat strong precipitation events. There were no data in such periods (usually for about a few hours). The data will be corrected and analyzed after the cruise.

(5) Data archive

The data archive server is set inside Kyushu University and the original data and the results of the analyses will be available from us. The data will be also submitted to JAMSTEC DMO.

5.8 Sky radiometer

(1) Personnel

Kazuma AOKI (University of Toyama)	*Principal Investigator / not on board
Tadahiro HAYASAKA (Tohoku University)	*not on board
Souichiro SUEYOSHI (GODI)	support for operation
Harumi OTA (GODI)	support for operation
Asuka DOI (GODI)	support for operation

(2) Objectives

Objective of the observations in this aerosol is to study distribution and optical characteristics of marine aerosols by using a ship-borne sky radiometer (POM-01 MKII: PREDE Co. Ltd., Japan). Furthermore, collections of the data for calibration and validation to the remote sensing data were performed simultaneously.

(3) Methods

Sky radiometer is measuring the direct solar irradiance and the solar aureole radiance distribution, has seven interference filters (0.34, 0.4, 0.5, 0.675, 0.87, 0.94, and 1.02 μm). Analysis of these data is performed by SKYRAD.pack version 4.2 developed by Nakajima *et al*. 1996.

(4) Results

Data obtained in this cruise will be analyzed at University of Toyama.

@ Measured parameters

- Aerosol optical thickness at five wavelengths (400, 500, 675, 870 and 1020 nm)
- Ångström exponent
- Single scattering albedo at five wavelengths
- Size distribution of volume (0.01 μm – 20 μm)

GPS provides the position with longitude and latitude and heading direction of the vessel, and azimuth and elevation angle of sun. Horizon sensor provides rolling and pitching angles.

(5) Data archives

Measurements of aerosol optical data are not archived so soon and developed, examined, arranged and finally provided as available data after certain duration. All data will archived at University of Toyama (K.Aoki, SKYNET/SKY: http://skyrad.sci.u-toyama.ac.jp/) after the quality check and submitted to JAMSTEC DIAG.

5.9 Sampling of rainfall, atmospheric vapor, seawaters

(1) Personnel

Naoyuki KURITA	(JAMSTEC)	Principal Investigator	*not on board
Souichiro SUEYOSHI	(Global Ocean Development Inc.: GODI)		
Harumi OTA	(GODI)		
Asuka DOI	(GODI)		

(2) Objective

It is known that the variability of stable water isotopes (HDO and $H_2^{18}O$) is closely related with the moisture origin and hydrological processes during the transportation from the source region to deposition site. Thus, water isotope tracer is recognized as a powerful tool to study hydrological cycles in the atmosphere. However, oceanic region is one of sparse region of the isotope data, it is necessary to fill the data to identify the moisture sources by using the isotope tracer. In this study, to fill this sparse observation area, intense water isotopes observation was conducted along the cruise track of MR10-03.

(3) Method

Following observation was carried out throughout this cruise.

- Atmospheric moisture sampling:

  Water vapor was sampled from the height about 20m above the sea level. The air was drawn at rate of 1.5-1.6L/min through a plastic tube attached to top of the compass deck. The flow rate is regulated according to the water vapor content to collect the sample amount 10-30ml. The water vapor was trapped in a glass trap submerged into an ethanol cooled to 100 degree C by radiator, and then they are collected every 12 hour during the cruise. After collection, water in the trap was subsequently thawed and poured into the 6ml glass bottle.

- Rainwater sampling

  Rainwater samples gathered in rain collector were collected just after precipitation events have ended. The collected sample was then transferred into glass bottle (6ml) immediately after the measurement of precipitation amount.

- Surface seawater sampling

  Seawater sample taken by the pump from 4m depth were collected in glass bottle (6ml) around the noon at the local time.

(4) Results

Sampling of water vapor for isotope analysis is summarized in Table 5.9.1 (94 samples). The detail of rainfall sampling (46 samples) is summarized in Table 5.9.2. Described rainfall amount is calculated from the collected amount of precipitation. Sampling of surface seawater taken by pump from 4m depths is summarized in Table 5.9.3 (46 samples).

(5) Data archive

Isotopes (HDO, $H_2^{18}O$) analysis will be done at RIGC/JAMSTEC, and then analyzed isotopes data will be submitted to JAMSTEC Data Integration and Analysis Group (DIAG).

Table 5.9.1 Summary of water vapor sampling for isotope analysis

Sample	Date	Time (UT)	Date	Time (UT)	Lon	Lat	Total (m^3)	MASS (ml)
V-1	5.5	06:38	5.5	13:00	143-28E	14-16N	0.61	12.0
V-2	5.5	13:02	5.6	01:00	142-19E	15-07N	1.15	22.0
V-3	5.6	01:01	5.6	13:00	140-39E	16-14N	1.15	23.0
V-4	5.6	13:04	5.7	01:00	139-29E	16-45N	1.14	22.6
V-5	5.7	01:04	5.7	13:00	139-29E	14-04N	1.14	19.5
V-6	5.7	13:03	5.8	01:02	139-29E	11-08N	1.15	22.0
V-7	5.8	01:06	5.8	13:01	141-06E	09-26N	1.14	20.8
V-8	5.8	13:05	5.9	01:01	141-50E	07-58N	1.14	21.4
V-9	5.9	01:03	5.9	13:01	140-01E	07-52N	1.15	23.0
V-10	5.9	13:04	5.10	01:03	139-30E	08-00N	1.15	23.8
V-11	5.10	01:05	5.10	13:00	136-36E	08-13N	1.15	20.0
V-12	5.10	13:03	5.11	01:00	133-49E	08-11N	1.15	22.2
V-13	5.11	01:01	5.11	13:00	134-12E	07-45N	1.15	21.9
V-14	5.11	13:02	5.13	22:56	134-15E	07-42N	0.95	18.8
V-15	5.13	07:56	5.13	14:02	133-42E	06-34N	0.58	10.0
V-16	5.13	14:04	5.14	02:00	133-30E	05-33N	1.14	21.9
V-17	5.14	02:00	5.14	14:00	135-25E	05-00N	1.15	23.6
V-18	5.14	14:01	5.15	2:00	138-13E	04-58N	1.15	21.8
V-19	5.15	2:01	5.15	14:00	139-30E	04-59N	1.15	21.9
V-20	5.15	14:03	5.16	2:00	139-31E	05-00N	1.15	21.9
V-21	5.16	2:00	5.16	14:00	139-31E	05-00N	1.15	22.6
V-22	5.16	14:02	5.17	2:00	139-30E	05-00N	1.15	20.9
V-23	5.17	2:00	5.17	14:00	139-31E	05-00N	1.15	23.4
V-24	5.17	14:00	5.18	2:00	139-30E	05-00N	1.15	20.3
V-25	5.18	2:00	5.18	14:00	139-30E	05-00N	1.16	25.4
V-26	5.18	14:03	5.19	2:00	139-30E	05-00N	1.11	22.0
V-27	5.19	02:01	5.19	14:01	139-31E	05-00N	1.15	24.0
V-28	5.19	14:03	5.20	2:00	139-30E	05-01N	1.15	22.1
V-29	5.20	2:01	5.20	14:00	139-31E	05-01N	1.15	23.8
V-30	5.20	14:01	5.21	2:00	139-30E	05-00N	1.15	21.1
V-31	5.21	2:02	5.21	14:00	139-30E	05-00N	1.15	23.9
V-32	5.21	14:00	5.22	2:00	139-31E	04-59N	1.15	21.1
V-33	5/22	02:03	5/22	14:00	139-30E	05-00N	1.15	23.6
V-34	5/22	14:01	5/23	02:00	139-30E	05-00N	1.15	21.4
V-35	5/23	02:01	5/23	14:00	139-30E	05-01N	1.15	22.6
V-36	5/24	14:01	5/24	02:00	139-31E	05-00N	1.15	21.5
V-37	5/24	02:02	5/24	14:00	139-30E	05-01N	1.14	23.4
V-38	5/24	14:02	5/25	02:00	139-31E	05-00N	1.14	21.0

V-39	5/25	02:01	5/25	14:00	139-31E	05-01N	1.15	20.8
V-40	5/25	14:01	5/26	02:00	139-31E	05-00N	1.14	21.4
V-41	5/26	02:01	5/26	14:00	139-31E	05-00N	1.15	21.8
V-42	5/26	14:02	5/27	02:00	139-30E	04-59N	1.14	22.0
V-43	5/27	02:01	5/27	14:00	139-31E	05-00N	1.15	23.2
V-44	5/27	14:01	5/28	02:00	139-31E	05-00N	1.15	22.0
V-45	5/28	02:02	5/28	14:00	139-30E	04-59N	1.15	21.6
V-46	5/28	14:03	5/29	02:00	139-30E	04-59N	1.15	21.8
V-47	5/28	02:02	5/29	14:00	139-31E	04-59N	1.15	21.2
V-48	5/29	14:01	5/30	02:00	139-31E	05-00N	1.15	22.8
V-49	5/30	02:01	5/30	14:00	139-30E	05-01N	1.15	22.0
V-50	5/30	14:01	5/31	02:00	139-31E	04-59N	1.15	22.6
V-51	5/31	02:01	5/31	14:00	139-30E	04-58N	1.15	
V-52	5/31	14:02	6/1	02:00	139-31E	04-59N	1.15	23.8
V-53	6/1	02:02	6/1	14:00	139-31E	05-00N	1.15	22.0
V-54	6/1	14:01	6/2	02:00	139-30E	05-01N	1.16	21.0
V-55	6/2	02:02	6/2	14:00	139-31E	05-00N	1.15	21.4
V-56	6/2	14:02	6/3	02:00	139-30E	05-02N	1.15	20.8
V-57	6/3	02:01	6/3	14:00	139-31E	04-59N	1.15	21.9
V-58	6/3	14:01	6/4	02:01	139-31E	05-00N	1.16	23.0
V-59	6/4	02:02	6/4	14:00	139-31E	04-59N	1.15	21.8
V-60	6/4	14:03	6/5	02:00	139-31E	05-01N	1.15	22.4
V-61	6/5	02:01	6/5	14:00	139-31E	04-59N	1.15	22.1
V-62	6/5	14:02	6/6	02:00	139-32E	05-00N	1.15	22.2
V-63	6/6	02:01	6/6	14:00	139-31E	04-59N	1.15	21.2
V-64	6/6	14:01	6/7	02:00	139-31E	05-00N	1.15	21.8
V-65	6/7	02:01	6/7	14:00	139-29E	04-59N	1.16	21.9
V-66	6/7	14:08	6/8	02:00	139-31E	04-58N	1.14	21.4
V-67	6/8	02:01	6/8	14:00	139-30E	04-59N	1.14	21.6
V-68	6/8	14:01	6/9	02:00	139-31E	05-00N	1.15	21.0
V-69	6/9	02:01	6/9	14:00	139-31E	04-59N	1.14	20.2
V-70	6/9	14:01	6/10	02:00	139-31E	05-01N	1.14	22.0
V-71	6/10	02:01	6/10	14:00	139-31E	05-00N	1.14	22.0
V-72	6/10	14:01	6/11	02:00	139-31E	05-00N	1.14	22.0
V-73	6/11	02:01	6/11	14:00	139-31E	04-59N	1.14	19.9
V-74	6/11	14:01	6/12	02:00	139-31E	05-01N	1.15	22.0
V-75	6/12	02:03	6/12	14:00	139-31E	04-59N	1.14	22.3
V-76	6/12	14:02	6/13	02:00	139-31E	05-00N	1.05	22.8
V-77	6/13	02:01	6/13	14:00	139-31E	04-59N	1.11	21.8
V-78	6/13	14:01	6/14	02:00	139-31E	04-59N	1.14	23.8
V-79	6/14	02:01	6/14	14:00	139-30E	04-59N	1.14	22.1

V-80	6/14	14:02	6/15	02:00	139-31E	05-01N	1.07	21.6
V-81	6/15	02:01	6/15	14:00	139-30E	04-59N	1.13	21.9
V-82	6/15	14:02	6/16	02:00	139-31E	05-00N	1.13	22.1
V-83	6/16	02:01	6/16	14:00	139-31E	05-00N	1.13	22.0
V-84	6/16	14:01	6/17	02:00	139-31E	05-01N	1.13	22.4
V-85	6/17	02:01	6/17	14:00	139-31E	05-00N	1.12	22.0
V-86	6/17	14:02	6/18	02:00	139-32E	05-00N	1.06	21.0
V-87	6/18	02:01	6/18	14:00	139-31E	04-59N	1.13	20.8
V-88	6/18	14:01	6/19	02:00	139-31E	05-00N	1.13	22.8
V-89	6/19	02:01	6/19	14:00	139-31E	05-00N	1.13	21.9
V-90	6/19	14:00	6/20	02:00	139-30E	05-01N	1.08	21.6
V-91	6/20	02:01	6/20	14:00	139-10E	05-00N	1.11	22.0
V-92	6/20	14:02	6/21	02:00	139-19E	05-00N	1.11	22.8
V-93	6/21	02:01	6/21	14:00	140-34E	04-34N	1.12	22.0
V-94	6/21	14:02	6/22	02:00	139-30E	04-22N	1.11	23.4

Table 5.9.2 Summary of precipitation sampling for isotope analysis.

	Date	Time (UT)	Lon	Lat	Date	Time (UT)	Lon	Lat	Rain (mm)
R-1	5.05	06:38	144-15E	13-41N	5/06	06:15	141-29E	15-39N	1.6
R-2	5.06	06:18	141-29E	15-39N	5/10	07:54	137-52E	08-00N	0.5
R-3	5.10	07:54	137-52	08-00N	5/14	07:25	133-50E	05-01N	0.5
R-4	5.14	07:29	133-51E	05-01N	5/14	13:44	135-21E	04-59N	1.4
R-5	5.14	13:45	135-22E	04-59N	5/15	02:10	138-15E	04-58N	1.1
R-6	5.15	02:10	138-15E	04-58N	5/17	01:53	139-31E	05-00N	0.1
R-7	5.17	01:53	139-31E	05-00N	5/19	19:15	139-32E	05-01N	6.6
R-8	5.19	19:15	139-32E	05-01N	5/20	01:45	139-30E	05-02N	7.9
R-9	5.20	01:45	139-30E	05-02N	5/20	14:05	139-31E	05-00N	2.2
R-10	5.20	14:06	139-31E	05-00N	5/21	00:41	139-29E	05-00N	1.3
R-11	5.21	00:41	139-29E	05-00N	5/22	02:09	139-30E	04:59N	1.9
R-12	5.22	02:09	139-30E	04-59N	5/23	07:22	139-29E	04:58N	24.3
R-13	5.23	07:23	139-29E	04-58N	5/23	18:26	139-31E	05-00N	1.1
R-14	5.23	18:28	139-31E	05-00N	5/24	05:04	139-31E	04-59N	0.6
R-15	5/24	05:05	139-31E	04-59N	5/24	07:19	139-32E	05-00N	1.4
R-16	5/24	07:19	139-32E	05-00N	5/24	13:35	139-30E	05-02N	4.2
R-17	5/24	13:35	139-30E	05-02N	5/25	07:34	139-32E	04-59N	5.9
R-18	5/25	07:34	139-32E	04-59N	5/26	07:50	139-31E	04-59N	0.4
R-19	5/26	07:50	139-31E	04-59N	5/26	10:13	139-30E	04-59N	4.7
R-20	5/26	10:13	139-30E	04-59N	5/26	16:53	139-31E	05-02N	0.3
R-21	5/26	16:55	139-31E	05-02N	5/27	13:29	139-31E	05-00N	3.1

R-22	5/27	13:30	139-31E	05-00N	5/29	02:04	139-30E	04-59N	8.2
R-23	5/29	02:07	139-30E	04-59N	5/29	06:40	139-31E	04-59N	3.0
R-24	5/29	06:41	139-31E	04-59N	5/31	02:05	139-31E	04-59N	8.2
R-25	5/31	02:06	139-31E	04-59N	5/31	07:42	139-33E	05-00N	0.,3
R-26	5/31	07:44	139-33E	05-00N	6/2	07:53	139-32E	05-00N	8.1
R-27	6/2	07:54	139-32E	05-00N	6/3	02:05	139-30E	05-01N	4.4
R-28	6/3	02:06	139-30E	05-01N	6/3	06:10	139-29E	05-00N	1.8
R-29	6/3	06:10	139-29E	05-00N	6/4	02:10	139-31E	05-00N	2.4
R-30	6/4	02:11	139-31E	05-00N	6/6	07:33	139-33E	05-00N	3.8
R-31	6/6	07:34	139-33E	05-00N	6/7	02:05	139-31E	05-00N	12.3
R-32	6/7	02:06	139-31E	05-00N	6/9	10:23	139-32E	04-49N	4.4
R-33	6/9	10:24	139-32E	04-59N	6/9	17:04	139-28E	05-00N	6.6
R-34	6/9	17:04	139-28E	05-00N	6/12	02:13	139-30E	05-00N	2.1
R-35	6/12	02:13	139-30E	05-00N	6/12	05:30	139-29E	04-59N	1.1
R-36	6/12	05:31	139-29E	04-59N	6/12	07:40	139-32E	04-59N	3.7
R-37	6/12	07:41	139-32E	04-59N	6/12	17:55	139-30E	04-59N	1.3
R-38	6/12	17:55	139-30E	04-59N	6/12	02:04	139-31E	05-00N	0.1
R-39	6/13	02:04	139-31E	05-00N	6/13	18:36	139-30E	04-59N	1.2
R-40	6/13	18:36	139-30E	04-59N	6/15	08:36	139-29E	04-59N	22.0
R-41	6/15	08:36	139-29E	04-59N	6/17	18:05	139-30E	05-00N	8.8
R-42	6/17	18:05	139-30E	05-00N	6/18	02:09	139-31E	05-00N	2.0
R-43	6/18	02:09	139-31E	05-00N	6/19	02:07	139-30E	04-59N	1.3
R-44	6/19	02:07	139-30E	04:59N	6/19	14:37	139-29E	04-59N	2.2
R-45	6/19	14:37	139-29E	04-59N	6/20	02:16	139-30E	05-00N	1.1
R-46	6/20	02:16	139-30E	05-00N	6/20	07:28	139-31E	04-57N	0.7

Table 5.9.3 Summary of water vapor sampling for isotope analysis

Sampling No.		Date	Time	Position	
			(UTC)	LON	LAT
MR10-03 O-	1	5.6	03:00	141-58E	15-20N
MR10-03 O-	2	5.7	03:01	139-30E	16-28N
MR10-03 O-	3	5.8	03:00	139-31E	10-58N
MR10-03 O-	4	5.9	03:00	141-27E	07-57N
MR10-03 O-	5	5.10	02:59	139-01E	08-00N
MR10-03 O-	6	5.11	03:00	133-30E	08-00N
MR10-03 O-	7	5.14	03:00	133-30E	05-19N
MR10-03 O-	8	5.15	03:00	138-27E	04-59N
MR10-03 O-	9	5.16	03:00	139-29E	05-00N
MR10-03 O-	10	5.17	03:00	139-30E	05-00N
MR10-03 O-	11	5.18	03:00	139-29E	05-00N
MR10-03 O-	12	5.19	03:00	139-30E	05-00N

MR10-03 O-	13	5.20	03:00	139-30E	05-00N
MR10-03 O-	14	5.21	03:00	139-29E	05-00N
MR10-03 O-	15	5.22	03:00	139-29E	05-00N
MR10-03 O-	16	5.23	03:00	139-30E	05-00N
MR10-03 O-	17	5.24	03:00	139-30E	05-00N
MR10-03 O-	18	5.25	03:00	139-30E	05-00N
MR10-03 O-	19	5.26	02:59	139-30E	05-00N
MR10-03 O-	20	5.27	03:00	139-30E	05-00N
MR10-03 O-	21	5.28	03:00	139-30E	05-00N
MR10-03 O-	22	5.29	03:00	139-30E	05-00N
MR10-03 O-	23	5.30	03:00	139-30E	05-00N
MR10-03 O-	24	5.31	03:00	139-30E	05-00N
MR10-03 O-	25	6.1	03:00	139-30E	05-00N
MR10-03 O-	26	6.2	03:00	139-30E	05-00N
MR10-03 O-	27	6.3	03:01	139-30E	05-00N
MR10-03 O-	28	6.4	03:00	139-30E	05-00N
MR10-03 O-	29	6.5	03:00	139-30E	05-00N
MR10-03 O-	30	6.6	03:00	139-30E	05-00N
MR10-03 O-	31	6.7	03:00	139-30E	05-00N
MR10-03 O-	32	6.8	03:00	139-30E	05-00N
MR10-03 O-	33	6.9	03:00	139-30E	05-00N
MR10-03 O-	34	6.10	03:00	139-30E	05-00N
MR10-03 O-	35	6.11	03:00	139-30E	05-00N
MR10-03 O-	36	6.12	03:00	139-30E	05-00N
MR10-03 O-	37	6.13	03:00	139-30E	05-00N
MR10-03 O-	38	6.14	03:00	139-30E	05-00N
MR10-03 O-	39	6.15	03:00	139-30E	05-00N
MR10-03 O-	40	6.16	03:00	139-30E	05-00N
MR10-03 O-	41	6.17	03:00	139-30E	05-00N
MR10-03 O-	42	6.18	03:00	139-30E	05-00N
MR10-03 O-	43	6.19	03:00	139-30E	05-00N
MR10-03 O-	44	6.20	03:00	139-30E	05-00N
MR10-03 O-	45	6.21	03:00	139-30E	05-00N
MR10-03 O-	46	6.22	03:00	139-30E	04-33N

5.10 Surface Meteorological Observations

(1) Personnel

Hiroyuki YAMADA	(JAMSTEC)	*Principal Investigator
Souichiro SUEYOSHI	(Global Ocean Development Inc., GODI)	
Harumi OTA	(GODI)	
Asuka DOI	(GODI)	
Ryo OHYAMA	(Mirai Crew)	

(2) Objectives

Surface meteorological parameters are observed as a basic dataset of the meteorology. These parameters provide the temporal variation of the meteorological condition surrounding the ship.

(3) Methods

Surface meteorological parameters were observed throughout the MR10-03 cruise. During this cruise, we used three systems for the observation.

i. MIRAI Surface Meteorological observation (SMet) system

Instruments of SMet system are listed in Table 5-10-1 and measured parameters are listed in Table 5.10-2. Data were collected and processed by KOAC-7800 weather data processor made by Koshin-Denki, Japan. The data set consists of 6-second averaged data.

ii. Shipboard Oceanographic and Atmospheric Radiation (SOAR) measurement system

SOAR system designed by BNL (Brookhaven National Laboratory, USA) consists of major three parts.

a) Portable Radiation Package (PRP) designed by BNL – short and long wave downward radiation.
b) Zeno Meteorological (Zeno/Met) system designed by BNL – wind, air temperature, relative humidity, pressure, and rainfall measurement.
c) Scientific Computer System (SCS) developed by NOAA (National Oceanic and Atmospheric Administration, USA) – centralized data acquisition and logging of all data sets.

SCS recorded PRP data every 6 seconds, while Zeno/Met data every 10 seconds. Instruments and their locations are listed in Table 5.10-3 and measured parameters are listed in Table 5.10-4.

iii. SeaSnake Skin Sea Surface Temperature (SSST)

To measure the skin sea surface temperature (SSST), the SeaSnake SSST-meter which is the floating thermistor designed by BNL was installed at the bow (5m extension). In this cruise, SSST was observed using two thermistors (107 Campbell, USA) from 01:51UTC 16th May 2010 to 06:03UTC 20th June 2010. We converted sensor output voltage to SSST by using Steinhart-Hart equation led by the calibration data. Each coefficient is as below.

Sensor	a	b	c
T01-005 Sensor:	8.53638e-04	-2.06254e-04	-8.37011e-08
T01-100 Sensor:	8.23313e-04	-2.10018e-04	-7.54940e-08

$y = a + b * x + c * x3,$
$x = \log (1 / ((Vref / V - 1) * R2 - R1))$
$T = 1 / y - 273.15$
Vref = 2500[mV], R1=249000[Ω], R2=1000[Ω]
T: Temperature [degC], V: Sensor output voltage [mV]

For the quality control as post processing, we checked the following sensors, before and after the cruise.

i. Young Rain gauge (SMet and SOAR)
Inspect of the linearity of output value from the rain gauge sensor to change Input value by adding fixed quantity of test water.

ii. Barometer (SMet and SOAR)
Comparison with the portable barometer value, PTB220CASE, VAISALA

iii. Thermometer (air temperature and relative humidity) (SMet and SOAR)
Comparison with the portable thermometer value, HMP41/45, VAISALA

(4) Preliminary results

Figure 5.10-1 shows the time series of the following parameters;

Wind (SMet)
Air temperature (SOAR)
Relative humidity (SOAR)
Precipitation (SOAR, rain gauge)
Short/long wave radiation (SOAR)
Pressure (SMet)
Sea surface temperature (SMet)
Significant wave height (SMet)

Figure 5.10-2 shows the time series of skin surface temperature (SSST) compared to sea surface temperature (EPCS). SSST was plotted using the data from T01-100 thermistors.

(5) Data archives

These meteorological data will be submitted to the Data Integration and Analysis Group (DIAG) of JAMSTEC just after the cruise.

(6) Remarks

i. SST (Sea Surface Temperature) data was available in the following periods.

08:30UTC 05th May 2010 to 06:26UTC 11th May 2010
07:45UTC 13th May 2010 to 06:30UTC 27th Jun. 2010

ii. Following periods, SSST (Skin Sea Surface Temperature) data was invalid due to adjustment of the sensor installation.

03:13 – 03:36UTC 17th May 2010.
01:56 – 02:09UTC 26th May 2010.
01:57 – 02:03UTC 16th Jun. 2010.

iii. Following periods, data acquisition was suspended in the territorial waters.

04:00UTC 05th May 2010 to 06:40UTC 05th May 2010 (Guam, U.S.A.)
22:58UTC 11th May 2010 to 07:50UTC 13th May 2010 (Republic of Palau)

Table 5.10-1: Instruents and installation locations of MIRAI Surface Meteorological observation system

Sensors	Type	Manufacturer	Location (altitude from surface)
Anemometer	KE-500	Koshin Denki, Japan	foremast (24 m)
Tair/RH	HMP45A	Vaisala, Finland with	
43408 Gill aspirated radiation shield		R.M. Young, USA	compass deck (21 m)
			starboard side and port side
Thermometer: SST	RFN1-0	Koshin Denki, Japan	4th deck (-1m, inlet -5m)
Barometer	Model-370	Setra System, USA	captain deck (13 m)
			weather observation room
Rain gauge	50202	R. M. Young, USA	compass deck (19 m)
Optical rain gauge	ORG-815DR	Osi, USA	compass deck (19 m)
Radiometer (short wave)	MS-801	Eiko Seiki, Japan	radar mast (28 m)
Radiometer (long wave)	MS-200	Eiko Seiki, Japan	radar mast (28 m)
Wave height meter	MW-2	Tsurumi-seiki, Japan	bow (10 m)

Table 5.10-2: Parameters of MIRAI Surface Meteorological observation system

Parameter	Units	Remarks
1 Latitude	degree	
2 Longitude	degree	
3 Ship’s speed	knot	Mirai log, DS-30 Furuno
4 Ship’s heading	degree	Mirai gyro, TG-6000, Tokimec
5 Relative wind speed	m/s	6sec./10min. averaged
6 Relative wind direction	degree	6sec./10min. averaged
7 True wind speed	m/s	6sec./10min. averaged
8 True wind direction	degree	6sec./10min. averaged
9 Barometric pressure	hPa	adjusted to sea surface level
		6sec. averaged
10 Air temperature (starboard side)	degC	6sec. averaged
11 Air temperature (port side)	degC	6sec. averaged
12 Dewpoint temperature (starboard side)	degC	6sec. averaged
13 Dewpoint temperature (port side)	degC	6sec. averaged
14 Relative humidity (starboard side)	%	6sec. averaged
15 Relative humidity (port side)	%	6sec. averaged
16 Sea surface temperature	degC	6sec. averaged
17 Rain rate (optical rain gauge)	mm/hr	hourly accumulation
18 Rain rate (capacitive rain gauge)	mm/hr	hourly accumulation
19 Down welling shortwave radiation	W/m2	6sec. averaged
20 Down welling infra-red radiation	W/m2	6sec. averaged
21 Significant wave height (bow)	m	hourly
22 Significant wave height (aft)	m	hourly
23 Significant wave period (bow)	second	hourly
24 Significant wave period (aft)	second	hourly

Table 5.10-3: Instruments and installation locations of SOAR system

Sensors (Zeno/Met)	Type	Manufacturer	Location (altitude from surface)
Anemometer	05106	R.M. Young, USA	foremast (25 m)
Tair/RH	HMP45A	Vaisala, Finland	
with 43408 Gill aspirated radiation shield			
		R.M. Young, USA	foremast (23 m)
Barometer	61202V	R.M. Young, USA	
with 61002 Gill pressure port		R.M. Young, USA	foremast (23 m)
Rain gauge	50202	R.M. Young, USA	foremast (24 m)
Optical rain gauge	ORG-815DA	Osi, USA	foremast (24 m)

Sensors (PRP)	Type	Manufacturer	Location (altitude from surface)
Radiometer (short wave)	PSP	Epply Labs, USA	foremast (25 m)
Radiometer (long wave)	PIR	Epply Labs, USA	foremast (25 m)
Fast rotating shadowband radiometer		Yankee, USA	foremast (25 m)

Table 5.10-4: Parameters of SOAR system

	Parameter	Units	Remarks
1	Latitude	degree	
2	Longitude	degree	
3	SOG	knot	
4	COG	degree	
5	Relative wind speed	m/s	
6	Relative wind direction	degree	
7	Barometric pressure	hPa	
8	Air temperature	degC	
9	Relative humidity	%	
10	Rain rate (optical rain gauge)	mm/hr	
11	Precipitation (capacitive rain gauge)	mm	reset at 50 mm
12	Down welling shortwave radiation	W/m2	
13	Down welling infra-red radiation	W/m2	
14	Defuse irradiance	W/m2	

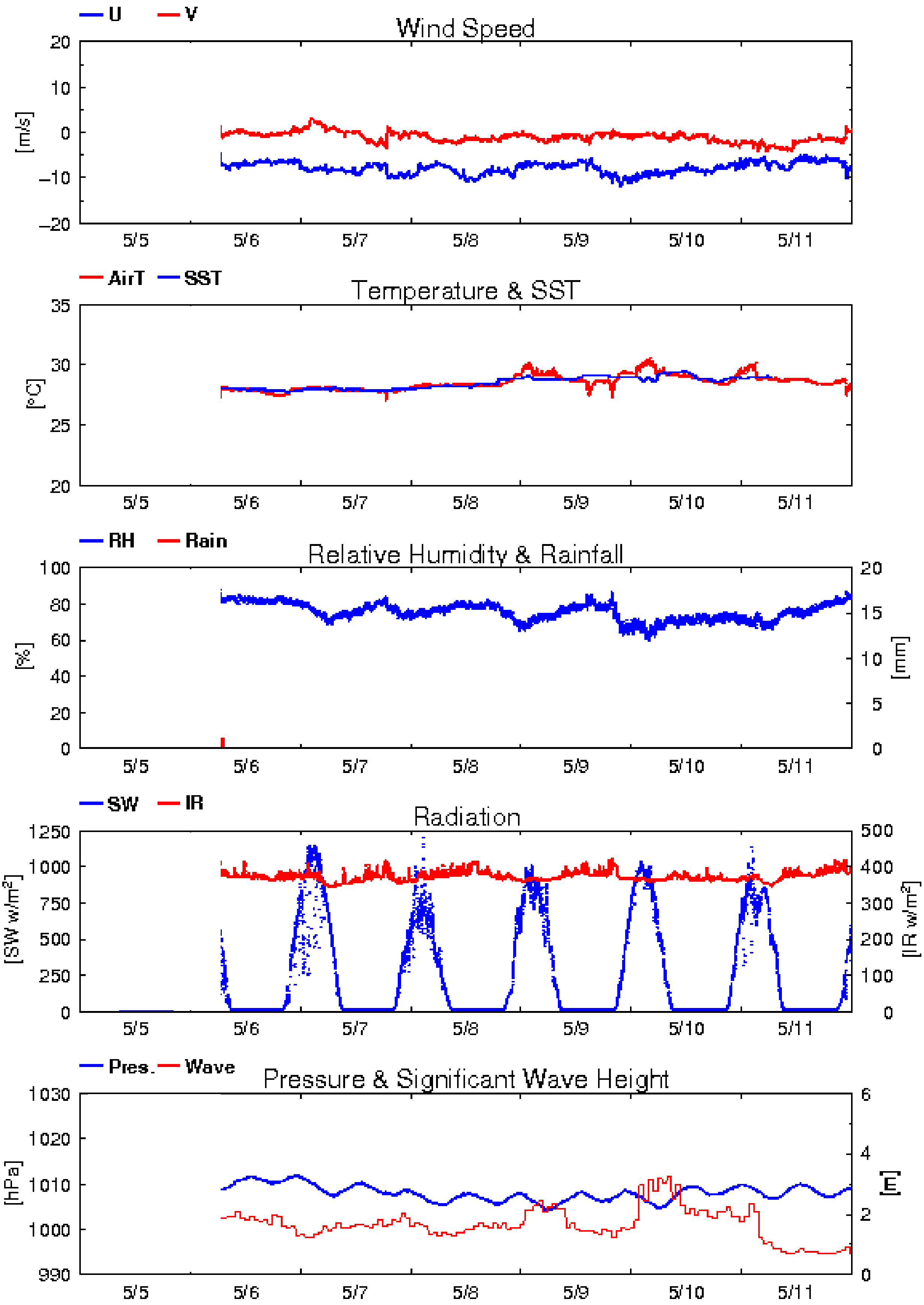

Fig. 5.10-1 Time series of surface meteorological parameters during the cruise

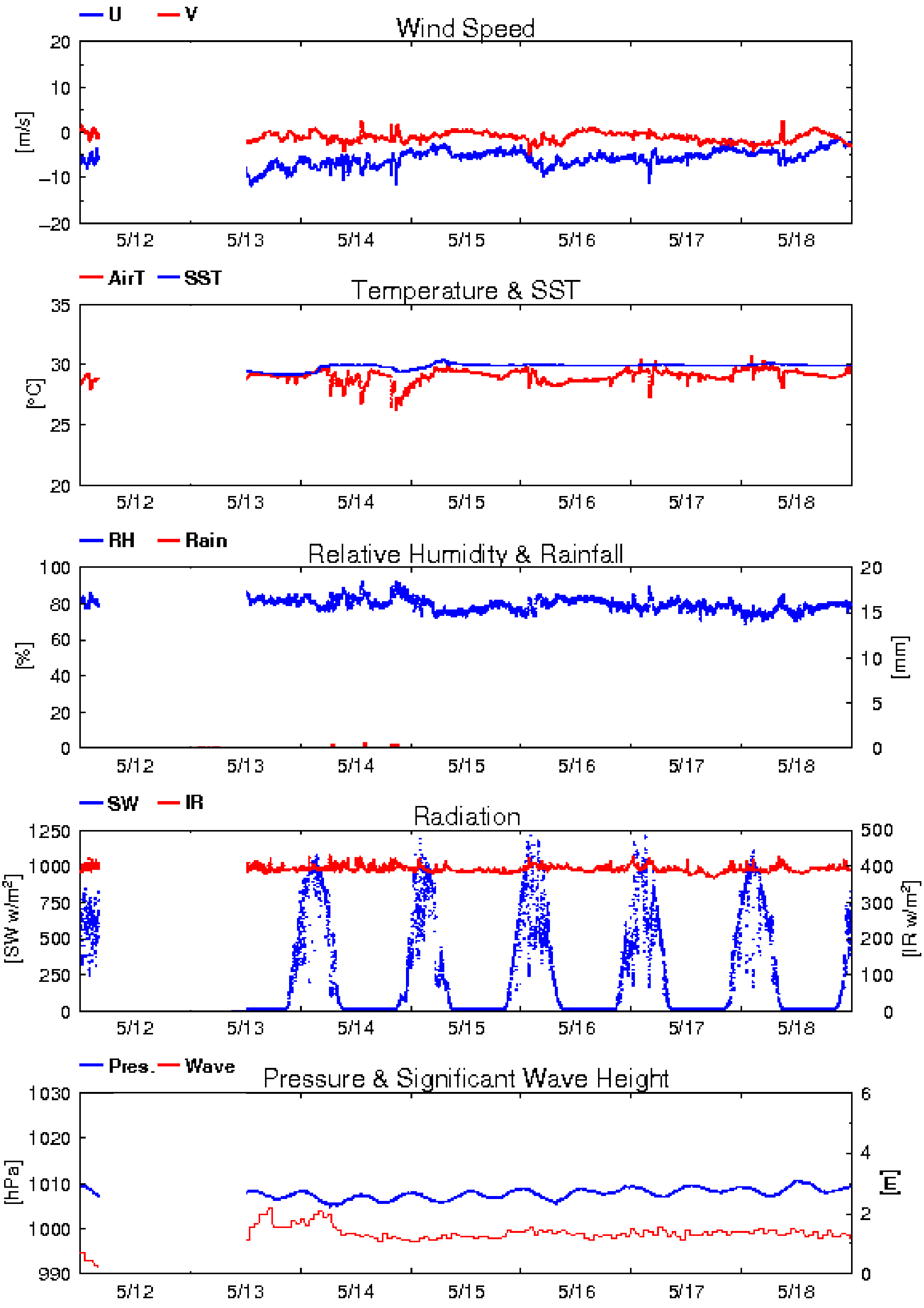

Fig. 5.10-1 (Continued)

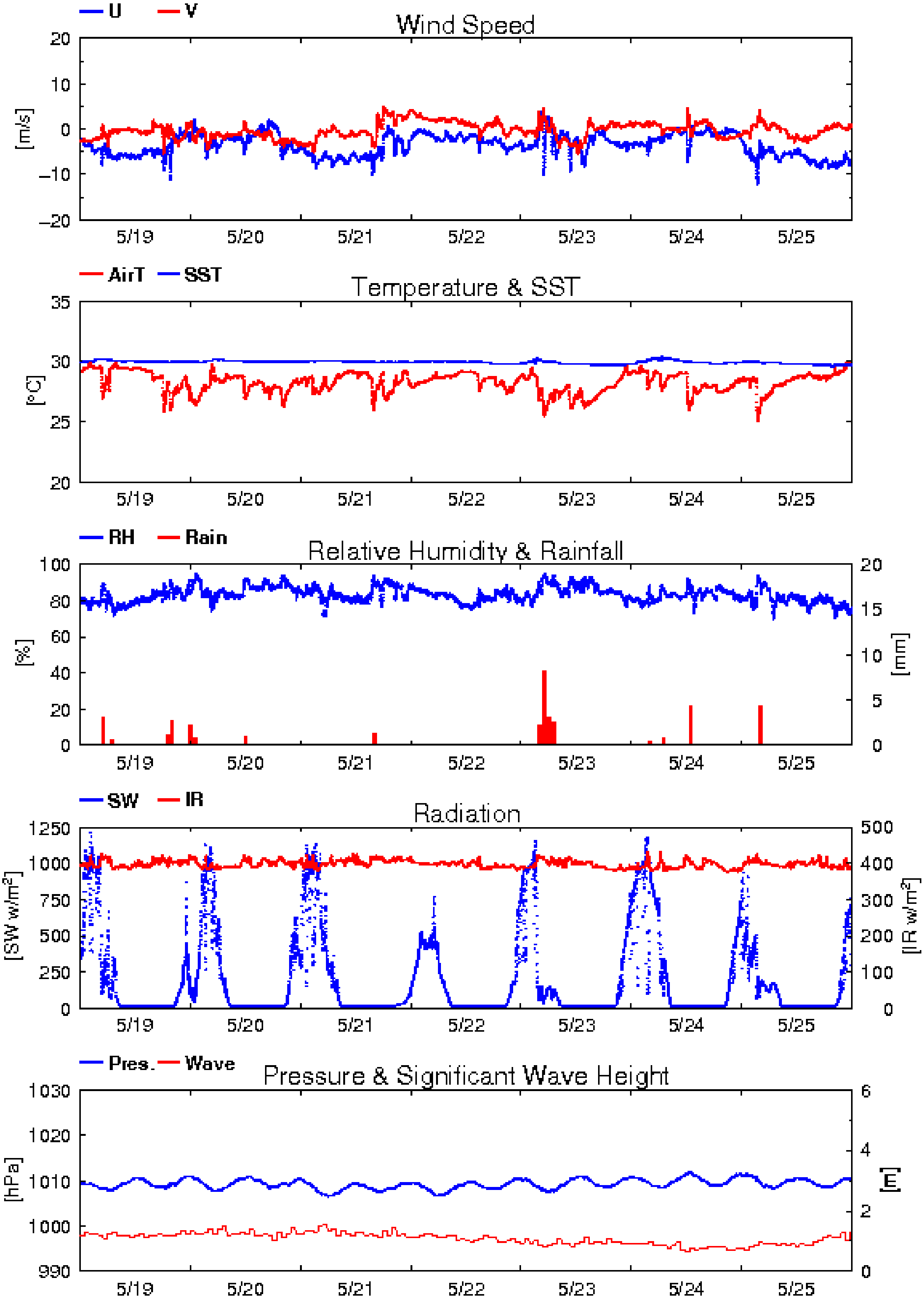

Fig. 5.10-1 (Continued)

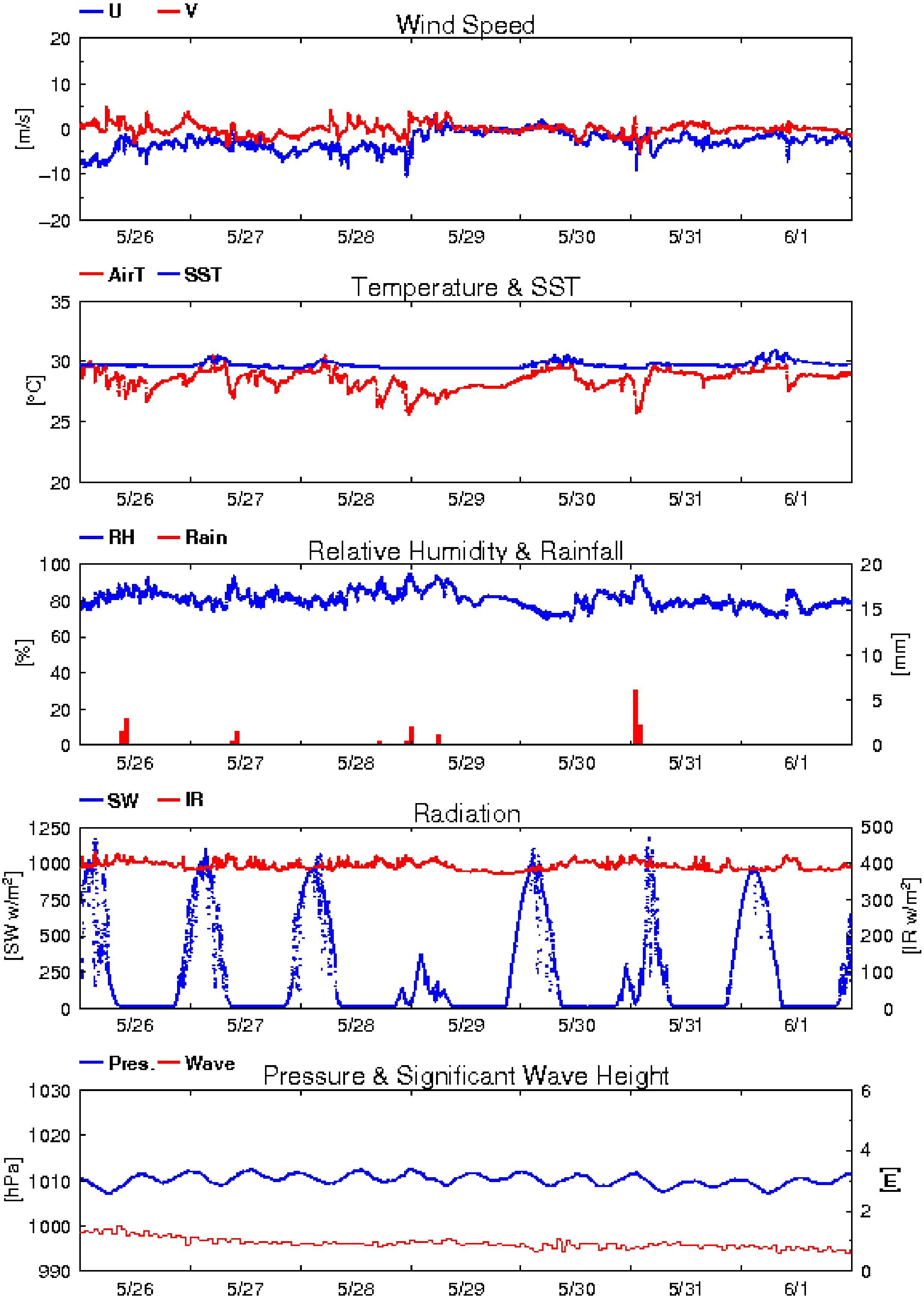

Fig. 5.10-1 (Continued)

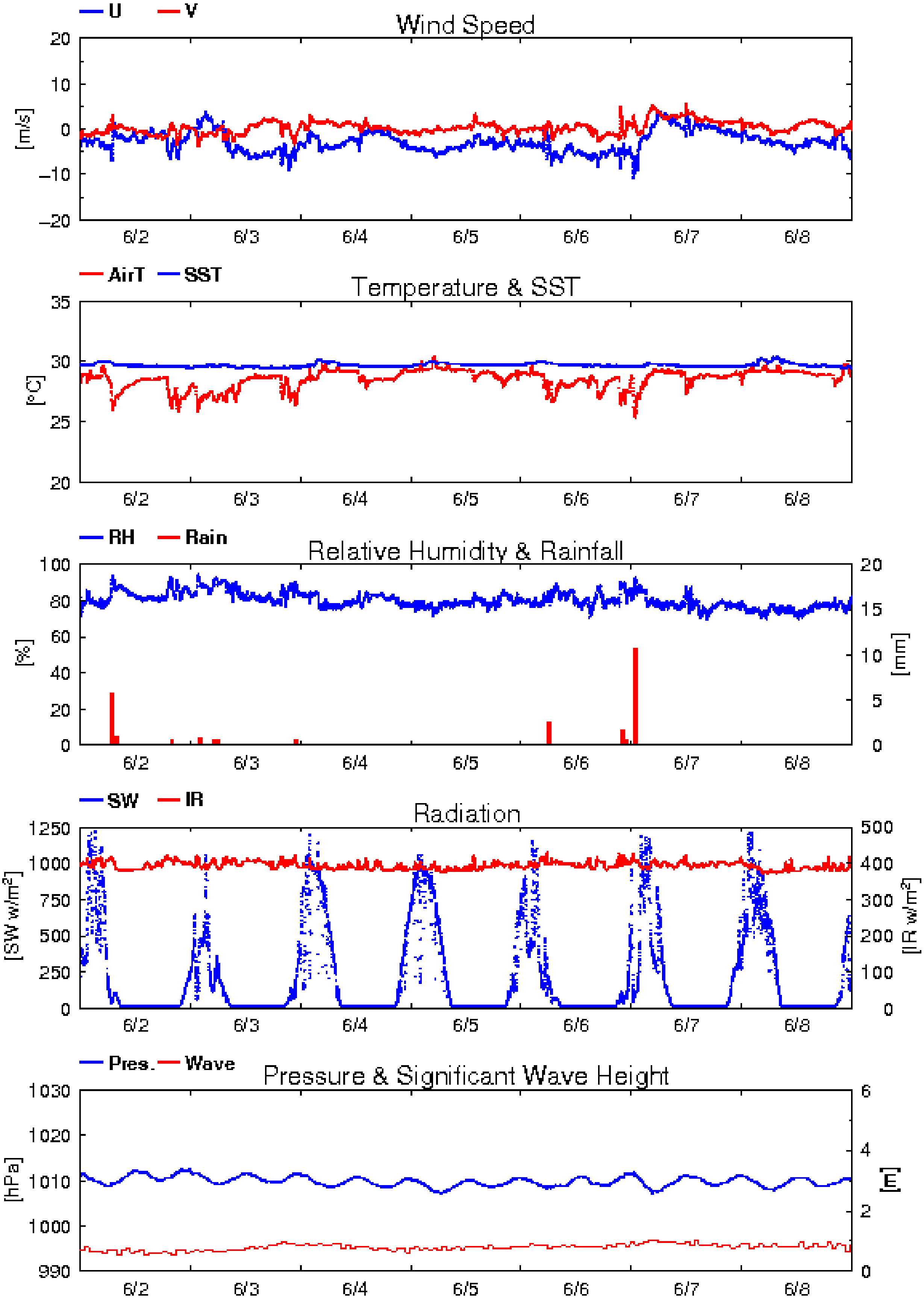

Fig. 5.10-1 (Continued)

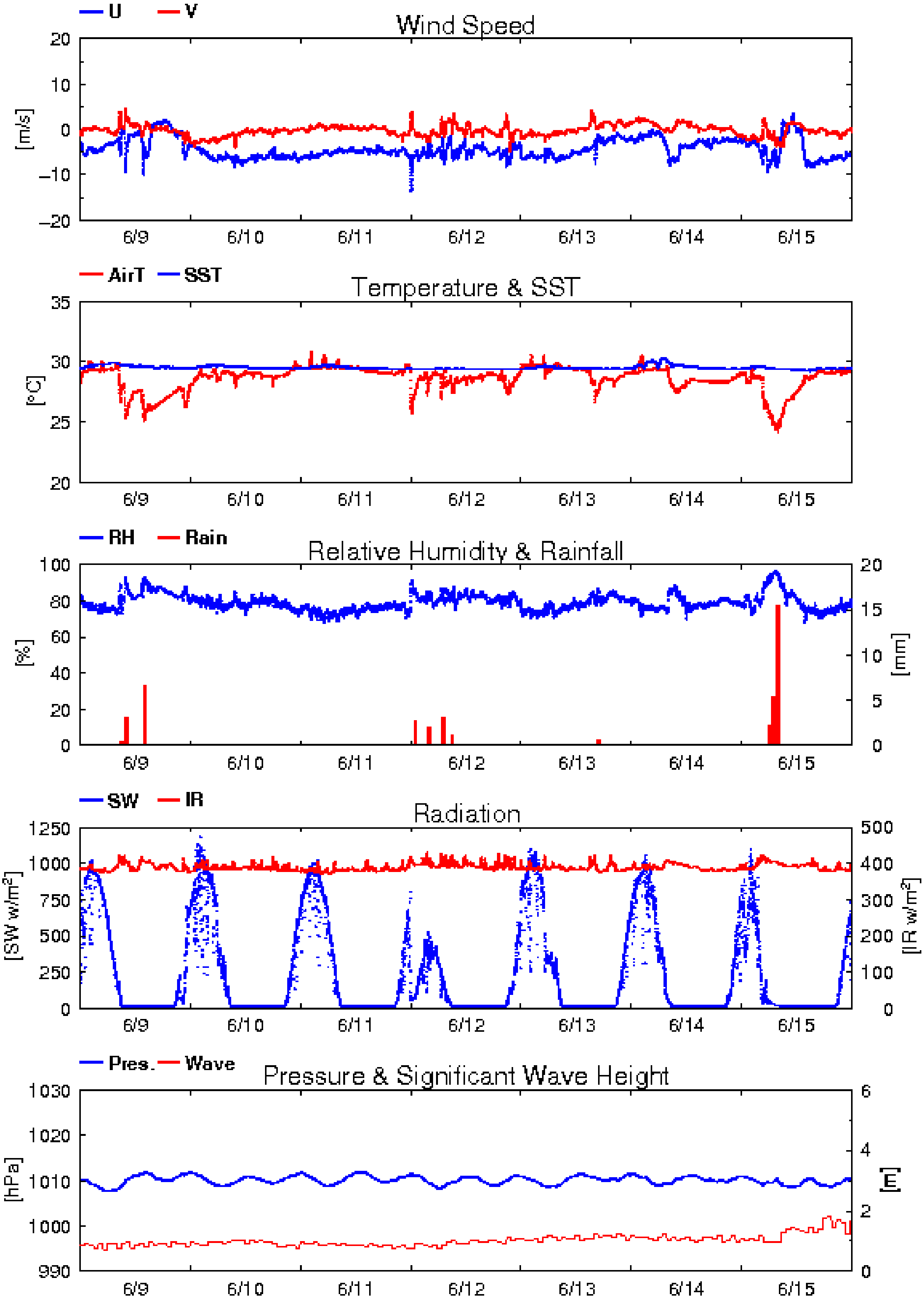

Fig. 5.10-1 (Continued)

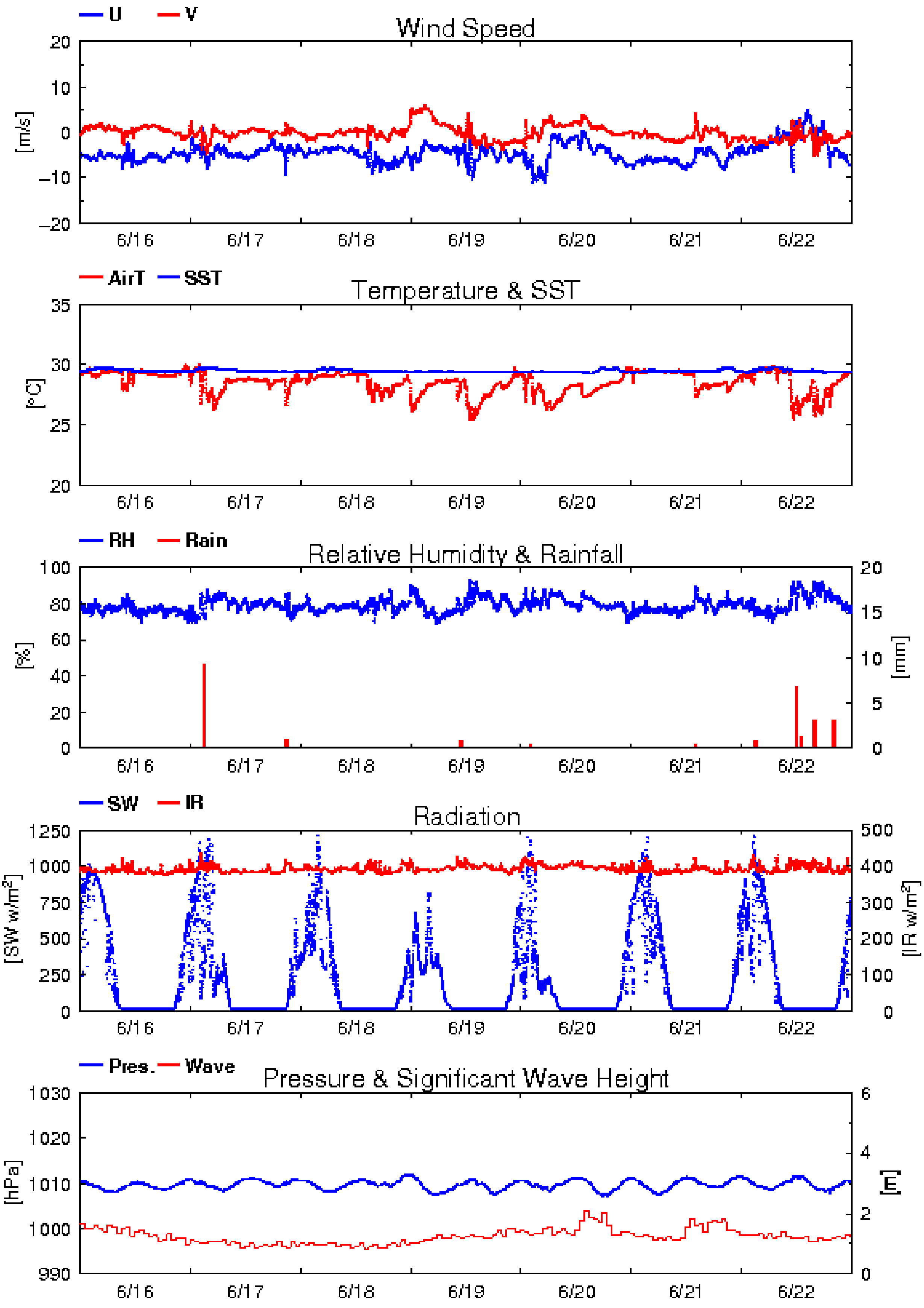

Fig. 5.10-1 (Continued)

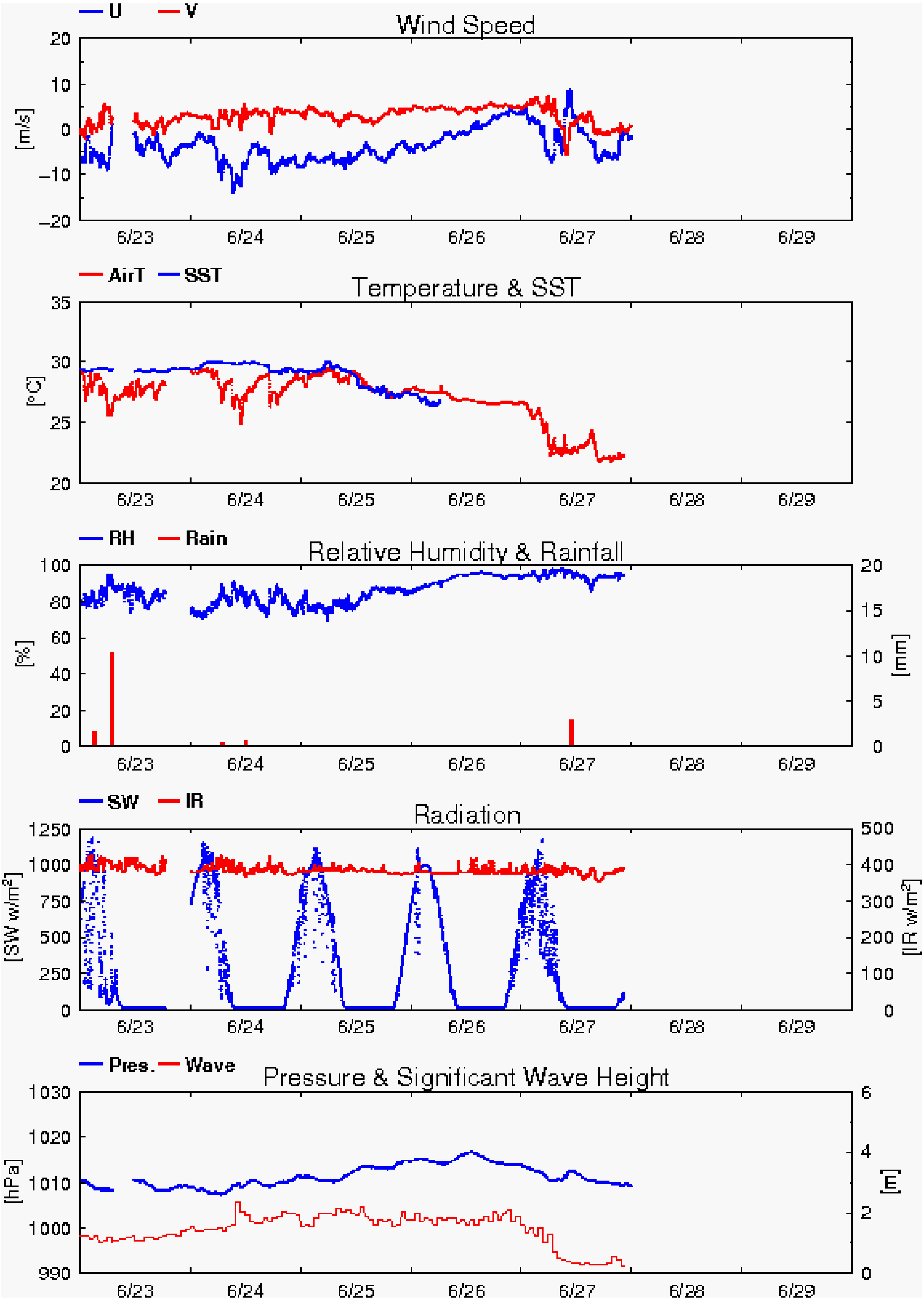

Fig. 5.10-1 (Continued)

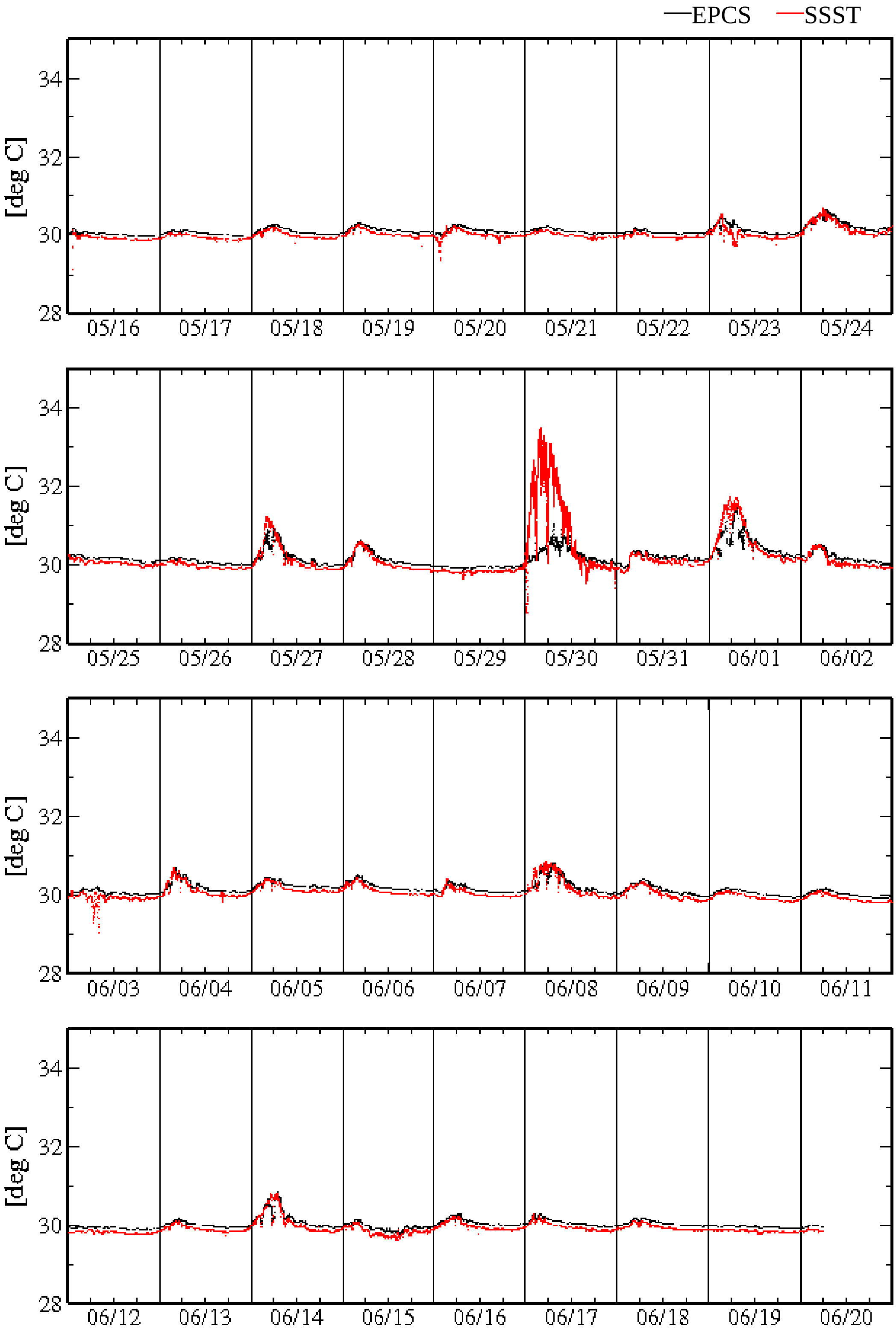

Fig. 5.10-2 Time series of Sea Surface Temperature (EPCS) and skin surface temperature(SSST) during the cruise.

5.11 Air-sea surface eddy flux measurement

(1) Personnel

Osamu TSUKAMOTO	(Okayama University)	Principal Investigator	* not on board
Fumiyoshi KONDO	(University of Tokyo)		* not on board
Hiroshi ISHIDA	(Kobe University)		* not on board
Souichiro SUEYOSHI	(Global Ocean Development Inc. (GODI))		
Harumi OTA	(GODI)		
Asuka DOI	(GODI)		

(2) Objective

To better understand the air-sea interaction, accurate measurements of surface heat and fresh water budgets are necessary as well as momentum exchange through the sea surface. In addition, the evaluation of surface flux of carbon dioxide is also indispensable for the study of global warming. Sea surface turbulent fluxes of momentum, sensible heat, latent heat, and carbon dioxide were measured by using the eddy correlation method that is thought to be most accurate and free from assumptions. These surface heat flux data are combined with radiation fluxes and water temperature profiles to derive the surface energy budget.

(3) Instruments and Methods

The surface turbulent flux measurement system (Fig. 5.11.1) consists of turbulence instruments (Kaijo Co., Ltd.) and ship motion sensors (Kanto Aircraft Instrument Co., Ltd.). The turbulence sensors include a three-dimensional sonic anemometer-thermometer (Kaijo, DA-600) and an infrared hygrometer (LICOR, LI-7500). The sonic anemometer measures three-dimensional wind components relative to the ship. The ship motion sensors include a two-axis inclinometer (Applied Geomechanics, MD-900-T), a three-axis accelerometer (Applied Signal Inc., QA-700-020), and a three-axis rate gyro (Systron Donner, QRS-0050-100). LI7500 is a CO_2/H_2O turbulence sensor that measures turbulent signals of carbon dioxide and water vapor simultaneously. These signals are sampled at 10 Hz by a PC-based data logging system (Labview, National Instruments Co., Ltd.). By obtaining the ship speed and heading information through the Mirai network system it yields the absolute wind components relative to the ground. Combining wind data with the turbulence data, turbulent fluxes and statistics are calculated in a real-time basis. These data are also saved in digital files every 0.1 second for raw data and every 1 minute for statistic data.

(4) Observation log

The observation was carried out throughout this cruise.

(5) Data Policy and citation

All data are archived at Okayama University, and will be open to public after quality checks and corrections. Corrected data will be submitted to JAMSTEC Marine-Earth Data and Information Department.

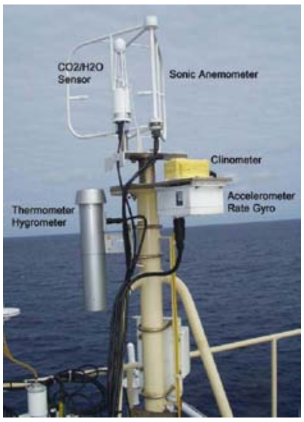

Fig. 5.11-1: Turbulent flux measurement system on the top deck of the foremast.

5.12 Continuous Monitoring of Surface Seawater

(1)Personal

Hiroyuki YAMADA	(JAMSTEC)	*Principal Investigator
Hironori SATO	(Marine Works Japan Co. Ltd)	*Operation Leader

(2)Objective

Our purpose is to obtain salinity, temperature, dissolved oxygen, and fluorescence data continuously in near-sea surface water during MR10-03 cruise.

(3)Instruments and Methods

The *Continuous Sea Surface Water Monitoring System* (Nippon Kaiyo Co. Ltd.) that equips five sensors of salinity, temperatures (two sensors), dissolved oxygen and fluorescence can continuously measure their values in near-sea surface water. Salinity is calculated by conductivity on the basis of PSS78. Specifications of these sensors are listed below.

This system is settled in the "*sea surface monitoring laboratory*" on R/V MIRAI, and near-surface water was continuously pumped up to the system through a vinyl-chloride pipe. The flow rate for the system is manually controlled by several valves with its value of 12 L min^{-1}. Flow rate is monitored with respective flow meter. The system is connected to shipboard LAN-system, and measured data is stored in a hard disk of PC every 1-minute together with time (UTC) and position of the ship.

a) Temperature and Conductivity sensor

Model	:	SBE-21, SEA-BIRD ELECTRONICS, INC.
Serial number	:	2126391-3126
Measurement range	:	Temperature -5 to +35℃, Conductivity 0 to 7 S m^{-1}
Resolution	:	Temperatures 0.001℃, Conductivity 0.0001 S m^{-1}
Stability	:	Temperature 0.01℃ 6 months^{-1}, Conductivity 0.001 S m^{-1} month^{-1}

b) Bottom of ship thermometer

Model	:	SBE 3S, SEA-BIRD ELECTRONICS, INC.
Serial number	:	032175
Measurement range	:	-5 to +35℃
Resolution	:	±0.001℃
Stability	:	0.002℃ year^{-1}

c) Dissolved oxygen sensor

Model	:	2127A, Hach Ultra Analytics Japan, INC.
Serial number	:	61230
Measurement range	:	0 to 14 ppm
Accuracy	:	±1% in ±5℃ of correction temperature
Stability	:	5% month^{-1}

e) Flow meter

Model	:	EMARG2W, Aichi Watch Electronics LTD.
Serial number	:	8672
Measurement range	:	0 to 30 L min^{-1}
Accuracy	:	<= ±1%
Stability	:	<= ±1% day^{-1}

(4)Measurements

Periods of measurement, maintenance, and problems during MR10-03 are listed in Table 5.12-1.

Table 5.12-1 Events list of the Sea surface water monitoring during MR10-03

System Date [UTC]	System Time [UTC]	Events	Remarks
06-May-2010	3:49	All the measurements started.	Leg 1 start
11-May-2010	6:26	All the measurements stopped.	Leg 1 end
13-May-2010	7:27	All the measurements started.	Leg 2 start
26-Jun-2010	6:25	All the measurements stopped.	Leg 2 end

(5)Preliminary Result

Preliminary data of temperature, salinity, dissolved oxygen and fluorescence at sea surface are shown in Fig.5.12-1. We took the surface water samples once a day to compare sensor data with bottle data of salinity and dissolved oxygen. The results are shown in Fig.5.12-2, 5.12-3. All the salinity samples were analyzed by the Guidline 8400B “AUTOSAL”, and dissolve oxygen samples were analyzed by Winkler method.

(6)Data archive

Data will be submitted to JAMSTEC Data Management Office (DMO).

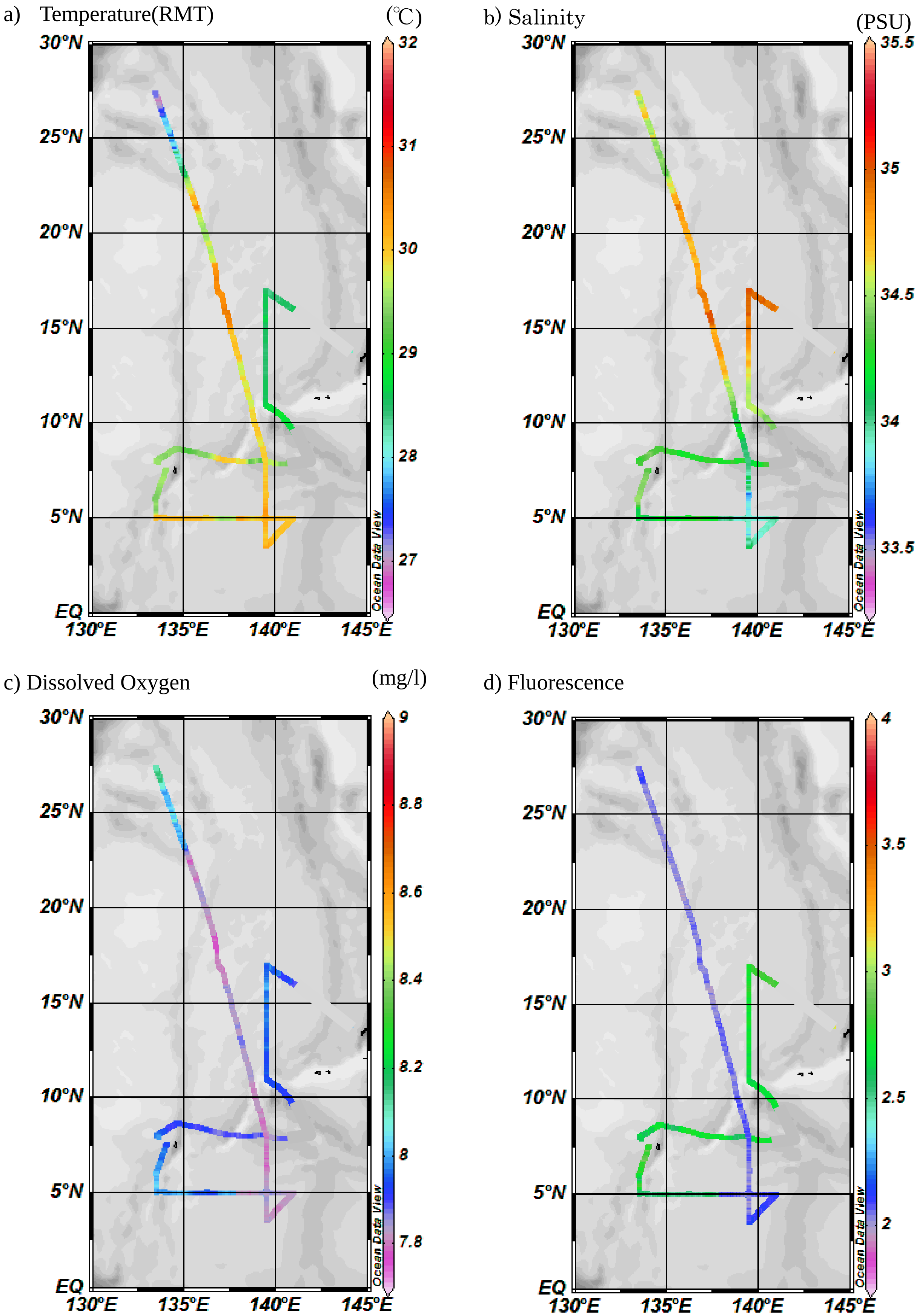

Fig.5.12-1 Spatial and temporal distribution of (a) temperature, (b) salinity, (c) dissolved oxygen and (d) fluorescence in MR10-03 cruise.

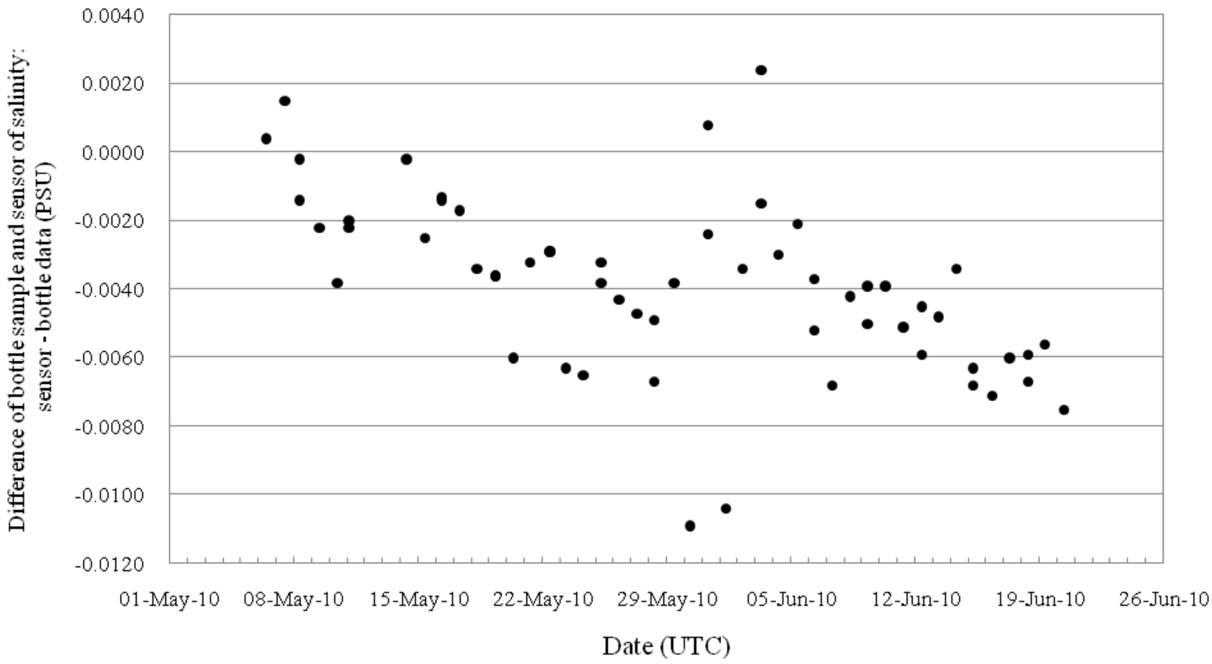

Fig.5.12-2 Difference of salinity between sensor data and bottle data.

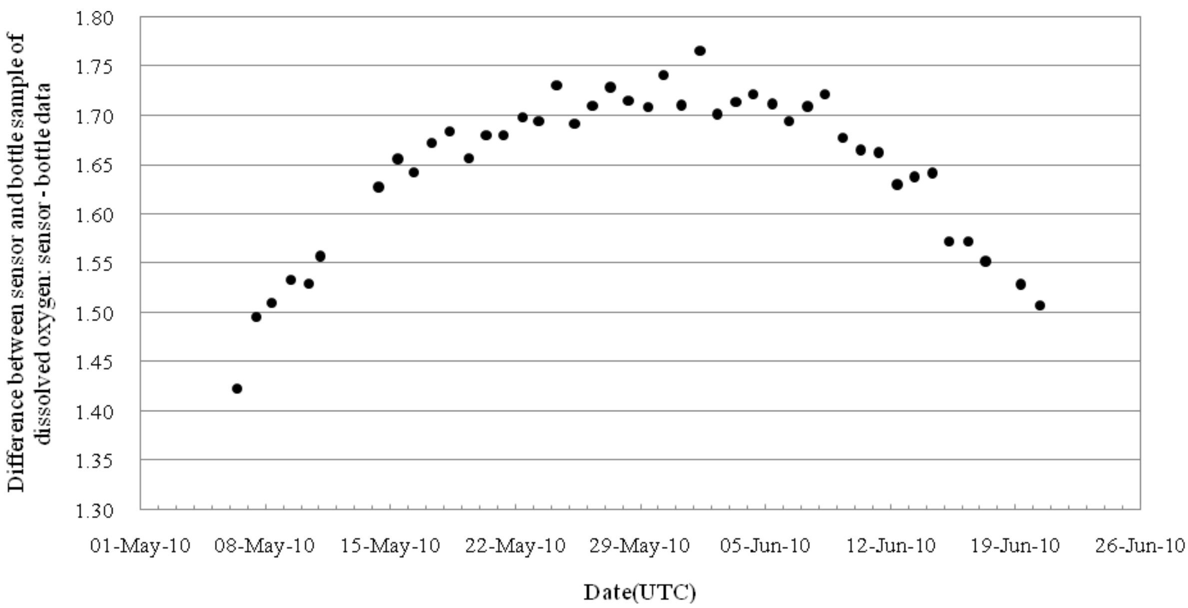

Fig.5.12-3 Difference of dissolved oxygen between sensor data and bottle data.

5.13 CTDO Profiling

(1) Personnel

Hiroyuki YAMADA	(JAMSTEC)	Principal Investigator
Kenichi KATAYAMA	(Marine Works Japan; MWJ)	Operation Leader
Fujio KOBAYASHI	(MWJ)	
Naoko TAKAHASHI	(MWJ)	
Shungo OSHITANI	(MWJ)	
Tamami UENO	(MWJ)	
Shinichiro YOKOGAWA	(MWJ)	
Masanori ENOKI	(MWJ)	
Hironori SATO	(MWJ)	
Tatsuya TANAKA	(MWJ)	

(2) Objective

Investigation of oceanic structure and water sampling

(3) Parameters

Temperature (Primary and Secondary)
Conductivity (Primary and Secondary)
Pressure
Dissolved Oxygen (Primary and Secondary)
Fluorescence

(4) Instruments and Methods

The CTD system, SBE 911plus system (Sea-Bird Electronics, Inc., USA), is a real time data system with the CTD data transmitted from a SBE 9plus underwater unit via a conducting cable to the SBE 11plus deck unit. The SBE 911plus system controls the 36-position SBE 32 Carousel Water Sampler. The Carousel accepts 12-litre Niskin-X water sample bottles (General Oceanics, Inc., USA). 15 out of 36 Niskin bottles were Teflon-coated and were washed by alkaline detergent and 1 N HCl.

The CTD raw data were acquired on real time by using the Seasave-Win32 (ver.7.20c) provided by Sea-Bird Electronics, Inc. and stored on the hard disk of the personal computer. Seawater was sampled during up cast by sending a command from the personal computer.

The CTD raw data was processed using SBE Data Processing-Win32 (ver.7.18d).

Data processing procedures and used utilities of SBE Data Processing-Win32 of were as follows:

DATCNV: DATCNV converted the raw data. DATCNV also extracted bottle information where scans were marked with the bottle confirm bit during acquisition.
Source of Scan Range = Bottle Log (BL) file
Offset = 0.0
Duration = 3.0

BOTTLESUM: BOTTLESUM created a summary of the bottle data.

ALIGNCTD: ALIGNCTD converted the time-sequence of oxygen sensor outputs into the pressure sequence to ensure that all calculations were made using measurements from the same parcel of water.
Advance Primary and secondary Oxygen Voltage = 3.0 sec

WILDEDIT: WILDEDIT marked extreme outliers in the data files.
Standard deviation for pass 1 = 10
Standard deviation for pass 2 = 20

Scan per block = 1000
Keep data within this distance of mean = 0
Exclude Scan Marked Bad = Check
Variables to Check for Wild Point = Pressure, Depth, Temperature, Conductivity, Oxygen Voltage

CELLTM: CELLTM removed conductivity cell thermal mass effects from measured conductivity.
Primary Alpha = 0.03 1/beta = 7.0
Secondary Alpha = 0.03 1/beta = 7.0

FILTER: FILTER performed a low pass filter on pressure with a time constant of 0.15 seconds.
Exclude Scan Marked Bad = Check

WFILTER: WFILTER performed a median filter to remove spikes in the Fluorometer data. A median value was determined from a window of 49 scans.

SECTIONU: SECTIONU removed the unnecessary data.

LOOPEDIT: LOOPEDIT marked scan with 'badflag', if the CTD velocity is less than 0 m/s.
Minimum Velocity Type = Fixed Minimum Velocity
Minimum CTD Velocity [m/sec] = 0.0
Exclude Scan Marked Bad = Check

DESPIKE: Remove spikes of the data. A median and mean absolute deviation was calculated in 1-dbar pressure bins for both down and up cast, excluding the flagged value.
Despike parameter = Temperature, Conductivity, Oxygen Voltage
Mean absolute deviation = 4
Despike times = 2

DERIVE: DERIVE was used to compute oxygen.
Time window docpt = seconds: 2
Tau Correction = yes

BINAVG: BINAVG calculate the averaged data in every 1 dbr.

DERIVE: DERIVE was re-used to compute salinity, sigma-theta and potential temperature.

SPLIT: SPLIT was used to split data into the down cast and the up cast.

The system used in this cruise is summarized as follows:

Under water unit: Sea-Bird Electronics, Inc. SBE9plus S/N 09P9833-0357
Pressure Sensor: Digiquartz pressure sensor S/N 42423
Deck unit: Sea-Bird Electronics, Inc. SBE11plus S/N 11P7030-0272
Carousel Water Sampler Sea-Bird Electronics, Inc. SBE32 S/N 3227443-0391
Water Sample bottle General Oceanics, Inc. 12-litre Niskin-X

Primary sensors
Temperature sensor: Sea-Bird Electronics, Inc. SBE03Plus S/N 03P2730
Calibrated Date: 02 Mar 2010
Conductivity sensor: Sea-Bird Electronics, Inc. SBE04-04/0 S/N 041203
Calibrated Date: 29 Jan 2010
Oxygen sensor: Sea-Bird Electronics, Inc. SBE43 S/N430949
Calibrated Date: 12 Jan 2010
Pump: Sea-Bird Electronics, Inc. SBE5T S/N052627

Secondary sensors
Temperature sensor: Sea-Bird Electronics, Inc. SBE03-04F S/N 031464
Calibrated Date: 10 Mar 2010

Conductivity sensor: Sea-Bird Electronics, Inc. SBE04-04/0 S/N 041206

Calibrated Date: 29 Jan 2010

Oxygen sensor: Sea-Bird Electronics, Inc. SBE43 S/N 430205

Calibrated Date: 13 Jun 2009

Pump: Sea-Bird Electronics, Inc. SBE5T S/N054595

Option sensor

Fluorescence sensor: Seapoint Sensors, Inc. Chlorophyll Fluorometer S/N3054

(5) Results

In total 304 casts of CTD measurements have been carried out (Table 5.13.1). Time-Pressure cross sections of temperature, salinity, dissolved oxygen, and fluorescence during intensive observation (Stn.09) are shown in Fig.5.13-1 and Fig.5.13-2.

(6) Data archive

Data will be submitted to JAMSTEC Data Management Office (DMO), and will be opened to public via R/V MIRAI Data Web site.

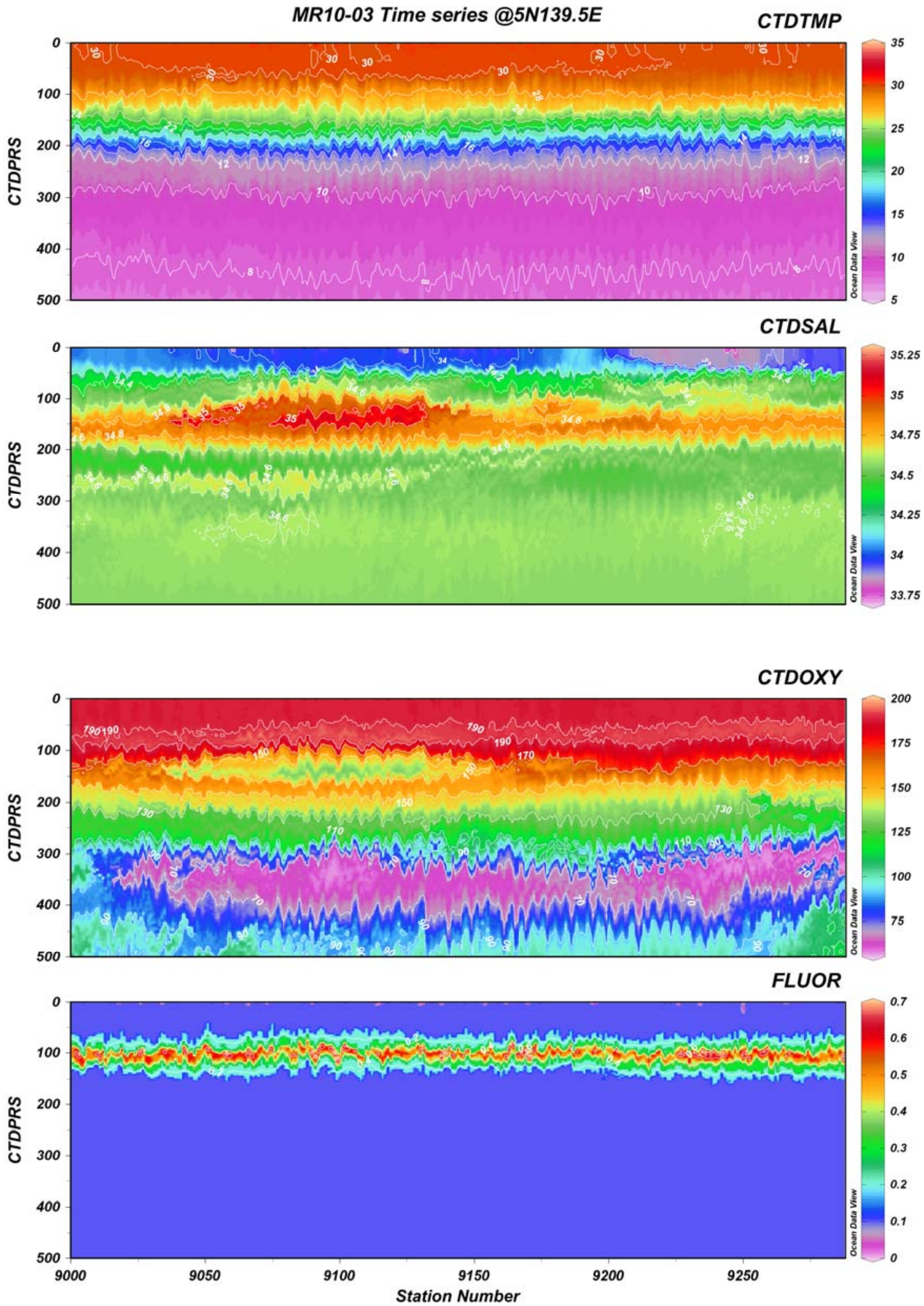

Fig. 5.13-1: Time-Pressure cross section of temperature, salinity, dissolved oxygen and fluorescence (Pressure from 0 to 500 db).

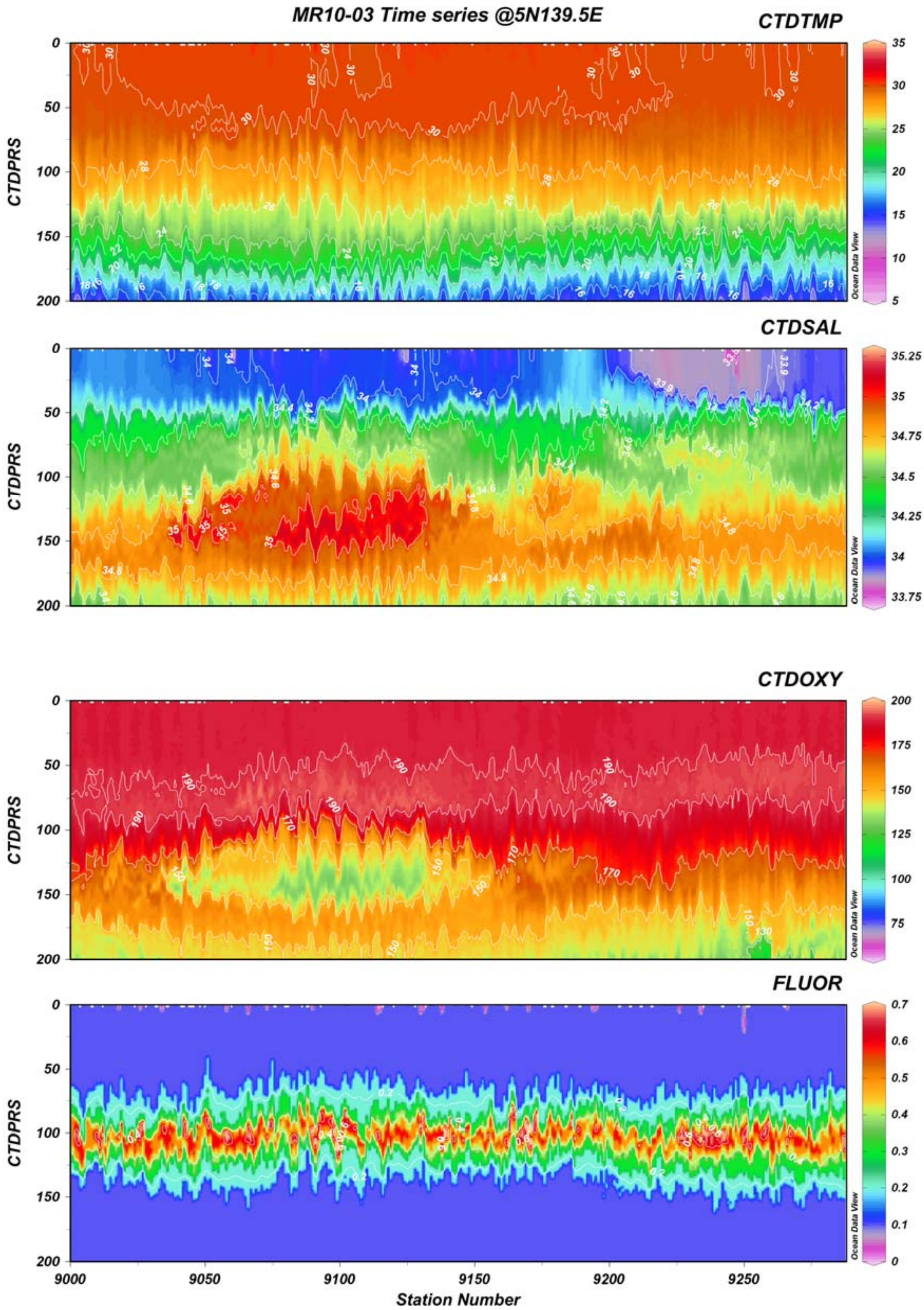

Fig. 5.13-2: Time-Pressure cross section of temperature, salinity, dissolved oxygen and fluorescence (Pressure from 0 to 200 db)

Table 5.13-1: CTD cast table

Stnnbr	Castno	Date(UTC) (mmddyy)	Time(UTC) Start	End	BottomPosition Latitude	Longitude	Depth	Wire Out	Max Depth	Max Pressure	CTD Filename	Remark
02	1	050610	22:39	22:57	16-59.93N	139-30.27E	4608.0	501.4	500.2	503.8	02M001	NEMO float deployed
03	1	050810	01:50	02:09	11-00.04N	139-29.89E	6278.0	505.5	500.4	503.8	03M001	NEMO float deployed
04	1	050810	23:08	23:27	07-59.99N	142-00.15E	3920.0	501.6	500.8	504.2	04M001	NEMO float deployed
05	1	050910	22:35	22:53	08-00.02N	139-30.09E	2783.0	503.3	500.5	504.0	05M001	NEMO float deployed
06	1	051110	04:06	04:25	08-00.13N	133-30.05E	4916.0	512.8	500.9	504.1	06M001	NEMO float deployed
07	1	051310	23:12	23:32	06-00.11N	133-29.95E	3511.0	506.2	500.7	504.3	07M001	NEMO float deployed
08	1	051410	05:01	05:23	05-00.33N	133-30.22E	4391.0	528.5	502.6	506.1	08M001	
09	1	051510	23:40	00:17	05-00.06N	139-30.14E	4183.0	502.3	501.0	503.8	09M001	
09	2	051610	02:40	02:58	05-00.05N	139-29.86E	4181.0	502.2	500.0	503.7	09M002	
09	3	051610	05:40	06:00	05-00.11N	139-29.90E	4180.0	504.5	500.8	504.6	09M003	
09	4	051610	08:42	09:03	05-00.08N	139-29.91E	4178.0	505.1	501.0	504.7	09M004	
09	5	051610	11:39	12:00	04-59.97N	139-30.04E	4179.0	558.8	556.3	560.4	09M005	
09	6	051610	14:40	15:01	04-59.96N	139-30.06E	4179.0	503.3	500.4	503.9	09M006	
09	7	051610	17:42	18:03	05-00.12N	139-29.94E	4181.0	512.2	501.7	505.4	09M007	
09	8	051610	20:41	21:02	05-00.12N	139-30.09E	4183.0	502.5	500.7	504.4	09M008	
09	9	051610	23:39	00:20	04-59.98N	139-30.02E	4181.0	502.5	501.2	504.8	09M009	
09	10	051710	02:38	02:57	04-59.93N	139-30.00E	4182.0	504.2	501.6	505.4	09M010	
09	11	051710	05:39	05:59	04-59.95N	139-29.88E	4180.0	501.8	500.8	504.0	09M011	
09	12	051710	08:40	09:00	05-00.08N	139-29.95E	4181.0	502.5	500.6	504.1	09M012	
09	13	051710	11:39	11:59	04-59.85N	139-29.98E	4178.0	501.4	500.5	503.5	09M013	
09	14	051710	14:40	14:58	05-00.00N	139-30.02E	4178.0	503.3	500.6	504.0	09M014	
09	15	051710	17:39	17:58	05-00.11N	139-30.05E	4180.0	506.2	500.6	504.1	09M015	
09	16	051710	20:42	21:02	05-00.28N	139-29.97E	4178.0	502.2	500.3	503.7	09M016	
09	17	051710	23:39	00:15	05-00.12N	139-30.13E	4180.0	502.5	500.3	504.2	09M017	
09	18	051810	02:40	02:58	04-59.98N	139-29.96E	4179.0	503.6	500.3	504.8	09M018	
09	19	051810	05:45	06:05	05-00.07N	139-30.00E	4180.0	502.5	500.9	504.4	09M019	
09	20	051810	08:44	09:04	05-00.13N	139-29.99E	4179.0	503.3	501.0	504.5	09M020	
09	21	051810	11:43	12:02	05-00.02N	139-29.84E	4180.0	502.3	500.9	503.9	09M021	
09	22	051810	14:43	15:02	04-59.99N	139-30.06E	4178.0	502.5	500.5	504.0	09M022	
09	23	051810	17:45	18:05	05-00.06N	139-30.02E	4179.0	502.2	500.3	504.1	09M023	
09	24	051810	20:43	21:04	05-00.18N	139-29.95E	4179.0	502.5	500.7	503.3	09M024	
09	25	051810	23:43	00:23	05-00.21N	139-30.07E	4180.0	501.8	500.3	503.5	09M025	
09	26	051910	02:42	03:01	05-00.02N	139-30.07E	4179.0	502.2	500.6	504.1	09M026	
09	27	051910	05:45	06:05	04-59.99N	139-29.99E	4180.0	501.8	500.3	503.8	09M027	
09	28	051910	08:45	09:06	05-00.06N	139-29.84E	4178.0	502.3	500.9	504.7	09M028	
09	29	051910	11:43	12:02	04-59.96N	139-29.93E	4178.0	504.0	500.4	504.0	09M029	
09	30	051910	14:44	15:03	05-00.01N	139-29.88E	4182.0	503.3	501.1	504.2	09M030	
09	31	051910	17:45	18:05	05-00.06N	139-30.04E	4179.0	502.2	500.1	503.5	09M031	
09	32	051910	20:45	21:06	05-00.14N	139-29.93E	4180.0	501.8	500.3	503.7	09M032	
09	33	051910	23:38	00:19	05-00.14N	139-30.12E	4181.0	503.6	501.2	504.3	09M033	
09	34	052010	02:44	03:03	05-00.10N	139-30.17E	4183.0	502.2	500.1	504.1	09M034	
09	35	052010	05:44	06:03	05-00.03N	139-30.03E	4179.0	501.8	500.3	503.7	09M035	
09	36	052010	08:44	09:06	05-00.07N	139-29.83E	4177.0	502.5	501.0	504.7	09M036	
09	37	052010	11:38	11:58	05-00.07N	139-29.97E	4180.0	502.7	500.5	504.1	09M037	
09	38	052010	14:44	15:03	05-00.04N	139-29.96E	4183.0	501.1	500.1	503.4	09M038	
09	39	052010	17:45	18:04	04-59.99N	139-30.07E	4180.0	501.6	500.6	503.0	09M039	
09	40	052010	20:46	21:07	05-00.13N	139-29.91E	4180.0	504.7	500.2	503.5	09M040	
09	41	052010	23:43	00:24	05-00.07N	139-30.11E	4181.0	500.0	499.8	502.9	09M041	
09	42	052110	02:44	03:04	05-00.00N	139-30.01E	4178.0	502.0	501.1	503.8	09M042	
09	43	052110	05:43	06:03	04-59.96N	139-29.95E	4180.0	503.1	500.7	503.9	09M043	
09	44	052110	08:43	09:03	04-59.99N	139-29.85E	4179.0	501.4	500.6	504.0	09M044	
09	45	052110	11:44	12:04	05-00.03N	139-29.89E	4181.0	502.0	500.6	504.4	09M045	
09	46	052110	14:44	15:04	04-59.92N	139-30.00E	4179.0	503.8	500.8	504.2	09M046	
09	47	052110	17:44	18:03	05-00.00N	139-30.02E	4180.0	503.8	500.6	504.6	09M047	
09	48	052110	20:47	21:07	05-00.10N	139-30.01E	4179.0	503.4	500.7	504.4	09M048	
09	49	052110	23:44	00:21	04-59.99N	139-29.91E	4178.0	503.4	500.7	504.4	09M049	
09	50	052210	02:44	03:03	05-00.09N	139-29.87E	4183.0	503.3	501.4	504.5	09M050	
09	51	052210	05:43	06:02	04-59.88N	139-29.97E	4179.0	503.6	500.7	504.6	09M051	
09	52	052210	08:45	09:05	05-00.11N	139-29.81E	4177.0	502.7	501.0	504.2	09M052	
09	53	052210	11:44	12:03	05-00.03N	139-29.78E	4177.0	503.3	500.8	504.2	09M053	
09	54	052210	14:44	15:03	04-59.99N	139-29.98E	4179.0	504.4	500.6	504.2	09M054	
09	55	052210	17:43	18:02	05-00.09N	139-30.16E	4182.0	502.0	500.4	503.0	09M055	
09	56	052210	20:44	21:04	05-00.05N	139-30.03E	4178.0	502.2	500.3	504.1	09M056	
09	57	052210	23:50	00:29	05-00.03N	139-30.03E	4176.0	502.7	500.8	504.3	09M057	
09	58	052310	02:43	03:02	05-00.03N	139-30.26E	4179.0	505.3	501.3	504.7	09M058	
09	59	052310	05:42	06:02	04-59.99N	139-30.00E	4183.0	502.5	500.8	504.2	09M059	
09	60	052310	08:45	09:04	04-59.95N	139-29.87E	4179.0	502.0	500.4	503.8	09M060	
09	61	052310	11:43	12:02	05-00.01N	139-29.84E	4180.0	502.7	501.2	504.1	09M061	
09	62	052310	14:45	15:04	05-00.00N	139-29.99E	4183.0	504.4	501.0	504.4	09M062	

Table 5.13-1 (continued)

Stnnbr	Castno	Date(UTC)	Time(UTC)		BottomPosition		Depth	Wire	Max	Max	CTD	Remark
		(mmddyy)	Start	End	Latitude	Longitude		Out	Depth	Pressure	Filename	
09	63	052310	17:42	18:03	04-59.94N	139-30.08E	4182.0	505.1	500.7	504.1	09M063	
09	64	052310	20:44	21:04	05-00.02N	139-30.15E	4180.0	502.3	500.5	503.8	09M064	
09	65	052310	23:43	00:23	04-59.98N	139-29.99E	4178.0	502.7	500.6	504.0	09M065	
09	66	052410	02:43	03:02	05-00.01N	139-30.13E	4178.0	502.9	500.6	503.9	09M066	
09	67	052410	05:42	06:01	04-59.92N	139-30.06E	4178.0	502.7	500.4	503.9	09M067	
09	68	052410	08:44	09:03	04-59.93N	139-29.96E	4182.0	502.3	500.2	503.7	09M068	
09	69	052410	11:43	12:02	05-00.00N	139-29.91E	4181.0	503.3	501.1	504.6	09M069	
09	70	052410	14:44	15:03	05-00.08N	139-29.96E	4181.0	503.6	500.4	503.8	09M070	
09	71	052410	17:44	18:03	05-00.05N	139-30.08E	4179.0	503.4	500.3	504.1	09M071	
09	72	052410	20:44	21:03	05-00.03N	139-29.96E	4181.0	501.6	500.5	503.6	09M072	
09	73	052410	23:44	00:21	05-00.12N	139-30.05E	4184.0	501.6	500.1	503.5	09M073	
09	74	052510	02:41	03:00	05-00.05N	139-30.05E	4181.0	502.7	500.3	504.0	09M074	
09	75	052510	05:44	06:03	04-59.95N	139-30.10E	4181.0	503.3	500.6	503.9	09M075	
09	76	052510	08:43	09:03	04-59.96N	139-29.94E	4178.0	504.5	500.8	504.3	09M076	
09	77	052510	11:44	12:02	04-59.98N	139-29.85E	4177.0	503.6	501.2	505.0	09M077	
09	78	052510	14:44	15:04	04-59.99N	139-29.92E	4182.0	502.9	500.7	504.2	09M078	
09	79	052510	17:44	18:03	05-00.08N	139-30.09E	4181.0	504.5	500.3	504.5	09M079	
09	80	052510	20:44	21:03	05-00.05N	139-29.91E	4181.0	501.4	500.2	503.5	09M080	
09	81	052510	23:43	00:20	05-00.04N	139-29.76E	4179.0	502.9	501.0	504.2	09M081	
09	82	052610	02:43	03:01	04-59.97N	139-29.88E	4180.0	503.8	500.6	504.0	09M082	
09	83	052610	05:42	06:01	05-00.05N	139-30.05E	4179.0	503.3	500.1	503.7	09M083	
09	84	052610	08:44	09:03	04-59.93N	139-29.92E	4178.0	503.6	500.5	503.9	09M084	
09	85	052610	11:43	12:02	05-00.03N	139-29.87E	4179.0	503.4	501.3	504.5	09M085	
09	86	052610	14:43	15:01	04-59.94N	139-29.97E	4181.0	502.9	500.1	503.6	09M086	
09	87	052610	17:44	18:04	05-00.14N	139-30.00E	4181.0	504.4	500.5	503.9	09M087	
09	88	052610	20:44	21:03	04-59.94N	139-30.04E	4178.0	502.5	500.3	503.6	09M088	
09	89	052610	23:07	00:05	05-00.02N	139-29.97E	4181.0	1015.3	1000.9	1008.8	09M089	
09	90	052710	02:42	03:00	05-00.03N	139-30.02E	4178.0	502.5	500.2	503.7	09M090	
09	91	052710	05:42	06:01	05-00.02N	139-30.10E	4179.0	504.5	501.0	504.9	09M091	
09	92	052710	08:44	09:03	04-59.97N	139-30.05E	4180.0	501.2	500.1	503.5	09M092	
09	93	052710	11:43	12:01	05-00.00N	139-29.98E	4184.0	502.0	500.7	504.1	09M093	
09	94	052710	14:42	15:01	05-00.05N	139-29.94E	4181.0	504.9	501.4	504.7	09M094	
09	95	052710	17:43	18:02	05-00.16N	139-30.12E	4177.0	502.3	500.2	503.7	09M095	
09	96	052710	20:44	21:03	05-00.00N	139-30.05E	4179.0	501.8	500.2	503.9	09M096	
09	97	052710	23:42	00:22	05-00.00N	139-29.94E	4178.0	502.0	501.1	504.4	09M097	
09	98	052810	02:42	03:01	05-00.00N	139-29.91E	4180.0	504.0	500.6	504.2	09M098	
09	99	052810	05:43	06:02	05-00.02N	139-30.06E	4177.0	502.9	500.8	504.2	09M099	
09	100	052810	08:41	09:00	05-00.08N	139-30.04E	4182.0	502.9	500.9	504.2	09M100	
09	101	052810	11:42	12:01	04-59.94N	139-29.96E	4177.0	503.1	500.6	504.0	09M101	
09	102	052810	14:42	15:02	05-00.08N	139-29.97E	4180.0	504.4	500.7	504.2	09M102	
09	103	052810	17:44	18:03	04-59.98N	139-30.05E	4178.0	503.6	500.6	504.3	09M103	
09	104	052810	20:44	21:03	04-59.98N	139-29.95E	4178.0	502.7	500.5	504.2	09M104	
09	105	052810	23:54	00:33	04-59.90N	139-29.99E	4178.0	502.5	500.9	504.2	09M105	
09	106	052910	02:39	02:58	04-59.92N	139-29.94E	4182.0	503.8	500.4	504.1	09M106	
09	107	052910	05:52	06:11	05-00.04N	139-29.91E	4182.0	506.0	500.6	504.1	09M107	
09	108	052910	08:44	09:04	04-59.85N	139-30.05E	4176.0	507.3	500.7	504.1	09M108	
09	109	052910	11:42	12:01	04-59.86N	139-29.95E	4176.0	504.2	501.0	504.6	09M109	
09	110	052910	14:43	15:02	04-59.97N	139-29.95E	4179.0	503.6	500.8	504.1	09M110	
09	111	052910	17:43	18:02	05-00.00N	139-30.02E	4183.0	503.1	500.4	503.8	09M111	
09	112	052910	20:43	21:02	05-00.02N	139-29.99E	4180.0	503.3	500.9	504.3	09M112	
09	113	052910	23:41	00:20	04-59.98N	139-29.98E	4179.0	504.2	501.5	505.3	09M113	
09	114	053010	02:43	03:01	05-00.00N	139-29.97E	4180.0	502.7	500.8	503.8	09M114	
09	115	053010	05:43	06:01	04-59.98N	139-29.93E	4180.0	502.9	500.1	503.9	09M115	
09	116	053010	08:43	09:02	04-59.98N	139-30.04E	4177.0	501.8	500.4	503.8	09M116	
09	117	053010	11:43	12:02	04-59.90N	139-29.98E	4179.0	502.5	500.7	504.1	09M117	
09	118	053010	14:54	15:13	04-59.97N	139-30.01E	4180.0	503.3	500.6	504.0	09M118	
09	119	053010	17:44	18:03	05-00.02N	139-29.98E	4180.0	502.7	500.3	503.8	09M119	
09	120	053010	20:43	21:02	05-00.04N	139-29.94E	4180.0	501.4	500.2	503.7	09M120	
09	121	053010	23:42	00:20	04-59.92N	139-29.90E	4181.0	502.2	500.4	503.5	09M121	
09	122	053110	02:43	03:01	04-59.93N	139-30.00E	4178.0	502.3	500.5	503.9	09M122	
09	123	053110	05:43	06:01	04-59.99N	139-29.95E	4179.0	502.9	500.3	503.8	09M123	
09	124	053110	08:42	09:01	04-59.97N	139-29.95E	4180.0	503.6	500.7	504.6	09M124	
09	125	053110	11:42	12:01	04-59.83N	139-29.80E	4179.0	503.3	500.6	504.0	09M125	
09	126	053110	14:44	15:02	05-00.00N	139-29.94E	4180.0	503.4	500.7	504.2	09M126	
09	127	053110	17:43	18:01	04-59.99N	139-29.99E	4181.0	502.9	500.3	503.7	09M127	
09	128	053110	20:43	21:02	05-00.02N	139-29.97E	4183.0	501.1	500.4	503.8	09M128	
09	129	053110	23:41	00:20	04-59.97N	139-29.91E	4182.0	503.1	500.3	503.8	09M129	
09	130	060110	02:41	03:00	04-59.99N	139-29.95E	4180.0	503.8	500.6	503.9	09M130	
09	131	060110	05:42	06:01	04-59.99N	139-29.99E	4181.0	503.8	500.4	503.8	09M131	
09	132	060110	08:43	09:02	05-00.00N	139-29.92E	4182.0	504.2	501.0	504.4	09M132	

Table 5.13-1 (continued)

Stnnbr	Castno	Date(UTC)	Time(UTC)		BottomPosition		Depth	Wire	Max	Max	CTD	Remark
		(mmddyy)	Start	End	Latitude	Longitude		Out	Depth	Pressure	Filename	
09	133	060110	11:42	12:01	04-59.99N	139-29.97E	4181.0	504.2	500.9	504.4	09M133	
09	134	060110	14:43	15:02	05-00.00N	139-30.02E	4181.0	502.7	500.7	504.0	09M134	
09	135	060110	17:42	18:01	05-00.00N	139-30.01E	4178.0	503.3	500.6	504.3	09M135	
09	136	060110	20:43	21:02	05-00.01N	139-30.01E	4178.0	502.2	500.7	504.1	09M136	
09	137	060110	23:08	00:07	05-00.01N	139-29.95E	4180.0	1009.3	1002.6	1010.6	09M137	
09	138	060210	02:45	03:03	04-59.97N	139-29.95E	4180.0	502.0	500.3	503.8	09M138	
09	139	060210	05:42	06:01	05-00.04N	139-29.98E	4180.0	503.1	500.5	503.9	09M139	
09	140	060210	08:43	09:02	04-59.98N	139-29.98E	4179.0	503.6	501.4	504.7	09M140	
09	141	060210	11:41	11:59	05-00.01N	139-30.02E	4178.0	503.4	500.8	504.0	09M141	
09	142	060210	14:43	15:01	05-00.01N	139-29.99E	4180.0	502.3	500.4	503.9	09M142	
09	143	060210	17:43	18:02	05-00.08N	139-29.99E	4178.0	502.9	500.6	504.1	09M143	
09	144	060210	20:44	21:03	05-00.06N	139-30.00E	4179.0	501.6	500.3	503.8	09M144	
09	145	060210	23:41	00:21	04-59.98N	139-30.02E	4178.0	502.5	500.3	504.1	09M145	
09	146	060310	02:41	02:59	05-00.03N	139-29.96E	4182.0	502.0	500.5	503.9	09M146	
09	147	060310	05:43	06:01	05-00.04N	139-29.94E	4179.0	502.7	500.7	504.1	09M147	
09	148	060310	08:42	09:01	05-00.00N	139-29.92E	4181.0	503.8	500.5	503.9	09M148	
09	149	060310	11:42	12:00	04-59.98N	139-29.99E	4178.0	501.2	500.1	503.6	09M149	
09	150	060310	14:43	15:02	05-00.00N	139-29.99E	4181.0	501.4	500.3	503.6	09M150	
09	151	060310	17:44	18:03	05-00.01N	139-30.05E	4181.0	504.0	500.7	504.3	09M151	
09	152	060310	20:43	21:02	05-00.01N	139-30.02E	4176.0	502.2	500.7	503.8	09M152	
09	153	060310	23:41	00:21	05-00.00N	139-30.00E	4179.0	503.4	500.9	504.3	09M153	
09	154	060410	02:43	03:01	04-59.94N	139-29.95E	4181.0	502.9	500.4	503.8	09M154	
09	155	060410	05:43	06:01	04-59.99N	139-29.87E	4179.0	503.4	500.3	503.9	09M155	
09	156	060410	08:43	09:02	05-00.01N	139-29.93E	4177.0	503.8	500.5	503.9	09M156	
09	157	060410	11:42	12:00	05-00.01N	139-29.96E	4180.0	503.1	500.3	503.5	09M157	
09	158	060410	14:43	15:02	05-00.01N	139-30.07E	4178.0	504.0	500.3	503.8	09M158	
09	159	060410	17:43	18:02	05-00.00N	139-30.02E	4181.0	503.8	500.6	504.1	09M159	
09	160	060410	20:43	21:03	05-00.02N	139-30.03E	4177.0	502.0	500.7	504.0	09M160	
09	161	060410	23:41	00:18	04-59.99N	139-30.01E	4181.0	503.3	500.7	504.3	09M161	
09	162	060510	02:42	03:00	04-59.93N	139-30.01E	4180.0	502.7	500.3	503.9	09M162	
09	163	060510	05:43	06:01	04-59.97N	139-29.98E	4181.0	503.4	500.3	504.2	09M163	
09	164	060510	08:43	09:01	04-59.99N	139-29.91E	4180.0	502.3	500.6	504.0	09M164	
09	165	060510	11:41	11:59	04-59.95N	139-29.90E	4183.0	502.5	500.2	503.4	09M165	
09	166	060510	14:44	15:02	05-00.00N	139-30.01E	4178.0	504.0	501.0	504.4	09M166	
09	167	060510	17:43	18:02	05-00.03N	139-30.03E	4181.0	502.3	500.5	503.7	09M167	
09	168	060510	20:43	21:03	05-00.00N	139-30.02E	4177.0	502.2	501.0	504.2	09M168	
09	169	060510	23:43	00:21	04-59.96N	139-30.05E	4181.0	502.2	500.4	503.3	09M169	
09	170	060610	02:42	03:00	04-59.96N	139-30.00E	4181.0	502.2	500.5	503.9	09M170	
09	171	060610	05:50	06:08	04-59.99N	139-29.99E	4181.0	502.5	500.8	504.4	09M171	
09	172	060610	08:44	09:03	04-59.97N	139-29.81E	4178.0	500.7	500.0	503.7	09M172	
09	173	060610	11:41	12:00	04-59.94N	139-29.89E	4182.0	502.7	500.4	503.8	09M173	
09	174	060610	14:42	14:59	04-59.96N	139-29.87E	4180.0	502.7	500.5	503.8	09M174	
09	175	060610	17:50	18:09	04-59.96N	139-29.98E	4181.0	503.8	500.8	504.2	09M175	
09	176	060610	20:43	21:02	04-59.99N	139-29.97E	4179.0	501.8	500.6	503.7	09M176	
09	177	060610	23:43	00:23	04-59.99N	139-29.98E	4177.0	503.1	500.7	504.1	09M177	
09	178	060710	02:42	03:00	04-59.96N	139-29.97E	4177.0	502.9	500.6	504.0	09M178	
09	179	060710	05:43	06:01	04-59.93N	139-29.99E	4178.0	503.1	500.8	504.2	09M179	
09	180	060710	08:43	09:02	05-00.02N	139-29.89E	4182.0	502.2	500.6	504.0	09M180	
09	181	060710	11:42	12:00	05-00.00N	139-29.94E	4179.0	503.6	500.4	503.6	09M181	
09	182	060710	14:43	15:00	04-59.98N	139-29.98E	4178.0	503.1	500.3	503.7	09M182	
09	183	060710	17:43	18:01	05-00.01N	139-30.02E	4180.0	503.1	500.5	504.2	09M183	
09	184	060710	20:44	21:03	05-00.00N	139-30.00E	4181.0	502.9	500.8	504.2	09M184	
09	185	060710	23:06	00:07	04-59.97N	139-29.98E	4181.0	1007.5	1000.6	1008.4	09M185	
09	186	060810	02:41	02:59	04-59.95N	139-30.03E	4177.0	501.6	500.8	504.2	09M186	
09	187	060810	05:42	06:00	04-59.89N	139-30.02E	4181.0	503.3	500.6	504.1	09M187	
09	188	060810	08:44	09:02	04-59.99N	139-29.97E	4179.0	502.0	500.3	503.6	09M188	
09	189	060810	11:41	11:59	05-00.02N	139-29.89E	4181.0	503.1	500.7	504.1	09M189	
09	190	060810	14:43	15:00	05-00.04N	139-29.97E	4179.0	504.5	501.1	504.5	09M190	
09	191	060810	17:41	18:00	05-00.04N	139-29.97E	4179.0	503.3	501.1	504.6	09M191	
09	192	060810	20:44	21:03	04-59.99N	139-30.00E	4183.0	501.8	500.4	503.7	09M192	
09	193	060810	23:40	00:20	05-00.06N	139-29.92E	4181.0	502.5	500.8	504.1	09M193	
09	194	060910	02:41	02:59	04-59.98N	139-29.99E	4178.0	501.6	500.7	504.1	09M194	
09	195	060910	05:08	05:45	05-00.00N	139-29.97E	4181.0	1008.0	1000.8	1008.8	09M195	
09	196	060910	08:44	09:02	05-00.06N	139-29.98E	4180.0	501.2	500.8	504.2	09M196	
09	197	060910	11:41	11:59	04-59.96N	139-29.93E	4179.0	503.3	500.9	504.3	09M197	
09	198	060910	14:42	15:00	04-59.97N	139-29.98E	4181.0	502.5	500.3	504.0	09M198	
09	199	060910	17:44	18:02	04-59.98N	139-29.88E	4182.0	502.3	500.8	503.9	09M199	
09	200	060910	20:43	21:03	05-00.00N	139-30.00E	4179.0	502.5	500.6	504.3	09M200	
09	201	060910	23:41	00:18	05-00.07N	139-29.87E	4178.0	503.3	500.6	503.9	09M201	
09	202	061010	02:42	03:00	04-59.92N	139-29.95E	4181.0	502.5	500.8	504.2	09M202	

Table 5.13-1 (continued)

Stnnbr	Castno	Date(UTC)	Time(UTC)		BottomPosition		Depth	Wire	Max	Max	CTD	Remark
		(mmddyy)	Start	End	Latitude	Longitude		Out	Depth	Pressure	Filename	
09	203	061010	05:42	06:00	04-59.99N	139-29.91E	4179.0	503.1	500.5	503.9	09M203	
09	204	061010	08:44	09:02	04-59.98N	139-29.89E	4180.0	502.5	500.2	503.8	09M204	
09	205	061010	11:42	11:59	04-59.96N	139-29.85E	4182.0	502.5	500.6	504.1	09M205	
09	206	061010	14:42	15:00	04-59.97N	139-29.92E	4178.0	503.3	500.9	504.3	09M206	
09	207	061010	17:43	18:01	05-00.02N	139-30.00E	4177.0	502.9	500.8	504.3	09M207	
09	208	061010	20:44	21:03	04-59.98N	139-29.96E	4181.0	502.0	500.7	504.0	09M208	
09	209	061010	23:41	00:20	05-00.01N	139-29.90E	4181.0	503.1	500.8	504.4	09M209	
09	210	061110	02:41	02:59	04-59.99N	139-29.88E	4177.0	502.5	500.6	504.0	09M210	
09	211	061110	05:42	06:00	05-00.02N	139-29.96E	4179.0	503.1	500.8	504.2	09M211	
09	212	061110	08:43	09:01	05-00.05N	139-29.95E	4180.0	502.7	500.4	503.8	09M212	
09	213	061110	11:41	11:59	05-00.00N	139-29.88E	4180.0	502.9	500.4	503.5	09M213	
09	214	061110	14:42	15:00	05-00.00N	139-29.99E	4179.0	503.1	500.4	503.8	09M214	
09	215	061110	17:44	18:02	05-00.00N	139-30.02E	4179.0	503.4	500.8	504.2	09M215	
09	216	061110	20:44	21:03	04-59.98N	139-30.01E	4179.0	501.6	500.5	503.7	09M216	
09	217	061110	23:41	00:18	05-00.08N	139-30.00E	4179.0	502.5	500.7	504.3	09M217	
09	218	061210	02:42	03:00	05-00.06N	139-29.95E	4180.0	501.8	500.2	503.6	09M218	
09	219	061210	05:42	06:00	05-00.05N	139-29.93E	4184.0	503.3	500.4	503.6	09M219	
09	220	061210	08:44	09:06	05-00.07N	139-29.95E	4182.0	503.1	500.6	504.1	09M220	
09	221	061210	11:42	12:03	05-00.00N	139-30.04E	4179.0	503.8	500.5	503.8	09M221	
09	222	061210	14:43	15:02	04-59.98N	139-30.00E	4182.0	502.5	500.0	503.7	09M222	
09	223	061210	17:45	18:04	04-59.98N	139-30.00E	4178.0	502.5	500.7	504.2	09M223	
09	224	061210	20:44	21:03	05-00.00N	139-30.04E	4179.0	504.2	501.3	504.6	09M224	
09	225	061210	23:42	00:19	04-59.97N	139-30.00E	4179.0	502.0	500.3	503.4	09M225	
09	226	061310	02:42	03:03	05-00.01N	139-29.84E	4180.0	502.2	500.1	503.7	09M226	
09	227	061310	05:42	06:02	05-00.00N	139-29.89E	4179.0	501.8	500.5	503.9	09M227	
09	228	061310	08:42	09:03	05-00.04N	139-29.96E	4179.0	551.8	550.2	554.0	09M228	
09	229	061310	11:41	12:01	04-59.99N	139-29.95E	4180.0	503.1	500.7	504.1	09M229	
09	230	061310	14:43	15:03	04-59.98N	139-30.00E	4179.0	502.3	500.4	503.7	09M230	
09	231	061310	17:42	18:02	04-59.97N	139-30.01E	4179.0	501.8	500.4	503.9	09M231	
09	232	061310	20:45	21:04	04-59.94N	139-29.99E	4178.0	501.8	500.3	503.7	09M232	
09	233	061310	23:06	00:06	04-59.94N	139-29.98E	4182.0	1006.6	1000.8	1008.5	09M233	
09	234	061410	02:42	03:01	04-59.92N	139-29.94E	4179.0	502.7	500.5	503.9	09M234	
09	235	061410	05:43	06:02	04-59.89N	139-29.93E	4179.0	502.2	500.6	504.0	09M235	
09	236	061410	08:42	09:01	05-00.00N	139-29.98E	4180.0	502.3	500.4	504.0	09M236	
09	237	061410	11:41	12:01	05-00.02N	139-29.94E	4181.0	503.8	500.3	503.7	09M237	
09	238	061410	14:42	15:02	04-59.92N	139-29.99E	4178.0	502.2	500.3	504.0	09M238	
09	239	061410	17:43	18:03	05-00.03N	139-29.98E	4179.0	503.1	500.6	504.0	09M239	
09	240	061410	20:42	21:02	05-00.02N	139-30.02E	4179.0	502.0	500.5	503.9	09M240	
09	241	061410	23:41	00:22	04-59.97N	139-29.96E	4180.0	502.2	500.4	503.7	09M241	
09	242	061510	02:42	03:01	04-59.99N	139-29.97E	4181.0	500.9	500.4	503.8	09M242	
09	243	061510	05:43	06:02	04-59.99N	139-29.83E	4179.0	502.0	500.9	504.3	09M243	
09	244	061510	08:42	09:01	04-59.93N	139-29.85E	4182.0	501.4	500.0	503.2	09M244	
09	245	061510	11:41	12:02	05-00.03N	139-29.91E	4181.0	503.4	501.1	504.5	09M245	
09	246	061510	14:41	15:01	04-59.96N	139-29.93E	4180.0	501.4	500.4	503.8	09M246	
09	247	061510	17:44	18:04	04-59.99N	139-30.00E	4180.0	502.2	500.3	503.5	09M247	
09	248	061510	20:43	21:03	04-59.98N	139-30.00E	4178.0	502.7	501.0	504.4	09M248	
09	249	061510	23:42	00:22	05-00.01N	139-29.93E	4182.0	501.4	500.4	503.8	09M249	
09	250	061610	02:41	03:01	04-59.99N	139-29.85E	4180.0	501.8	500.8	504.2	09M250	
09	251	061610	05:43	06:02	04-59.95N	139-29.89E	4182.0	501.8	500.1	503.5	09M251	
09	252	061610	08:43	09:03	05-00.03N	139-29.93E	4181.0	504.4	502.5	505.9	09M252	
09	253	061610	11:41	12:01	05-00.08N	139-29.98E	4181.0	502.5	500.1	503.3	09M253	
09	254	061610	14:43	15:02	04-59.99N	139-29.95E	4182.0	502.9	500.3	503.7	09M254	
09	255	061610	17:43	18:03	05-00.01N	139-29.99E	4180.0	503.3	500.9	504.3	09M255	
09	256	061610	20:44	21:04	05-00.05N	139-30.05E	4181.0	502.0	500.7	504.0	09M256	
09	257	061610	23:41	00:23	05-00.03N	139-29.98E	4180.0	501.8	500.7	504.0	09M257	
09	258	061710	02:40	03:00	05-00.15N	139-30.01E	4182.0	501.2	500.1	503.4	09M258	
09	259	061710	05:43	06:02	04-59.99N	139-30.00E	4182.0	502.5	500.8	503.9	09M259	
09	260	061710	08:43	09:03	05-00.05N	139-29.94E	4180.0	502.0	500.1	503.5	09M260	
09	261	061710	11:41	12:00	05-00.06N	139-29.95E	4181.0	502.0	500.3	503.3	09M261	
09	262	061710	14:42	15:02	05-00.00N	139-30.00E	4180.0	502.5	500.5	503.8	09M262	
09	263	061710	17:43	18:03	05-00.05N	139-30.05E	4181.0	502.3	500.3	503.9	09M263	
09	264	061710	20:45	21:06	05-00.16N	139-30.03E	4180.0	508.8	501.4	504.8	09M264	
09	265	061710	23:42	00:21	05-00.02N	139-30.04E	4183.0	502.0	500.5	504.2	09M265	
09	266	061810	02:41	03:00	05-00.01N	139-30.02E	4180.0	502.3	500.4	503.8	09M266	
09	267	061810	05:43	06:02	05-00.00N	139-30.02E	4179.0	502.3	500.7	504.0	09M267	
09	268	061810	08:43	09:03	05-00.01N	139-29.97E	4182.0	502.0	500.7	504.1	09M268	
09	269	061810	11:42	12:01	05-00.05N	139-29.94E	4181.0	501.1	500.0	503.4	09M269	
09	270	061810	14:41	15:01	05-00.11N	139-29.99E	4181.0	504.5	500.8	504.2	09M270	
09	271	061810	17:42	18:03	05-00.07N	139-30.02E	4181.0	504.0	501.4	504.8	09M271	
09	272	061810	20:43	21:04	04-59.95N	139-30.04E	4177.0	501.2	500.3	503.7	09M272	

Table 5.13-1 (continued)

Stnnbr	Castno	Date(UTC)	Time(UTC)		BottomPosition		Depth	Wire	Max	Max	CTD	Remark
		(mmddyy)	Start	End	Latitude	Longitude		Out	Depth	Pressure	Filename	
09	273	061810	23:42	00:22	05-00.06N	139-29.98E	4180.0	502.9	500.7	504.0	09M273	
09	274	061910	02:51	03:10	05-00.01N	139-30.03E	4180.0	502.7	500.8	504.2	09M274	
09	275	061910	05:43	06:02	04-59.99N	139-29.99E	4182.0	501.6	500.0	503.4	09M275	
09	276	061910	08:43	09:03	05-00.01N	139-29.95E	4183.0	501.2	500.2	503.6	09M276	
09	277	061910	11:42	12:02	05-00.01N	139-30.00E	4186.0	502.3	500.2	503.3	09M277	
09	278	061910	14:42	15:01	05-00.01N	139-29.97E	4182.0	502.9	500.4	503.8	09M278	
09	279	061910	17:42	18:02	05-00.04N	139-30.01E	4182.0	505.3	501.3	504.8	09M279	
09	280	061910	20:44	21:05	05-00.00N	139-30.02E	4180.0	501.2	500.7	503.5	09M280	
09	281	061910	23:06	00:09	05-00.12N	139-29.99E	4183.0	1006.2	1000.0	1008.0	09M281	
09	282	062010	02:41	03:01	05-00.03N	139-29.94E	4178.0	501.6	500.5	503.8	09M282	
09	283	062010	05:43	06:02	04-59.95N	139-30.00E	4179.0	505.1	500.2	503.0	09M283	
09	284	062010	08:43	09:04	05-00.03N	139-29.89E	4180.0	502.2	500.0	503.6	09M284	
09	285	062010	11:42	12:02	05-00.03N	139-29.95E	4182.0	502.3	500.1	503.5	09M285	
10	1	062010	19:03	19:25	05-00.03N	138-00.02E	4368.0	504.2	500.8	504.2	10M001	
11	1	062010	23:06	23:27	05-00.00N	138-45.01E	4284.0	502.9	501.3	504.8	11M001	
09	286	062110	03:07	03:27	04-59.99N	139-29.96E	4181.0	501.8	500.0	503.2	09M286	
12	1	062110	07:01	07:20	05-00.00N	140-15.03E	4171.0	501.8	500.2	503.6	12M001	
13	1	062110	11:07	11:27	05-00.00N	141-00.04E	3955.0	502.3	500.4	503.7	13M001	
14	1	062110	21:04	21:24	03-30.05N	139-30.02E	4419.0	501.1	500.3	503.7	14M001	
15	1	062210	01:07	01:27	04-15.03N	139-29.97E	4364.0	501.1	500.2	503.7	15M001	
09	287	062210	05:04	05:23	05-00.04N	139-30.01E	4183.0	502.3	500.2	504.0	09M287	
16	1	062210	09:08	09:27	05-45.09N	139-29.86E	4686.0	506.6	500.3	503.7	16M001	
17	1	062210	13:06	13:27	06-30.01N	139-30.04E	3637.0	502.0	501.0	504.5	17M001	
18	1	062210	20:08	20:28	07-59.99N	139-29.98E	2783.0	502.2	500.5	503.9	18M001	

5.14 Salinity of Sampled Water

(1) Personnel

Hiroyuki YAMADA	(JAMSTEC)	Principal Investigator
Fujio KOBAYASHI	(Marine Works Japan; MWJ)	Operation Leader
Syungo OSHITANI	(MWJ)	
Tamami UENO	(MWJ)	

(2) Objective

To provide a calibration for the measurement of salinity of bottle water collected on the CTD casts and EPCS

(3) Method

a. Salinity Sample Collection

Seawater samples were collected with 12 liter Niskin-X bottles and EPCS. The salinity sample bottle of the 250ml brown glass bottle with screw cap was used for collecting the sample water. Each bottle was rinsed three times with the sample water, and was filled with sample water to the bottle shoulder. The sample bottle was sealed with a plastic insert thimble and a screw cap ; the thimble being thoroughly rinsed before use. The bottle was stored for more than 24 hours in the laboratory before the salinity measurement.

The kind and number of samples taken are shown as follows ;

Table 5.14-1 Kind and number of samples

Kind of Samples	Number of Samples
Samples for CTD	144
Samples for EPCS	58
Total	202

b. Instruments and Method

The salinity analysis was carried out on R/V MIRAI during the cruise of MR10-03 using the salinometer (Model 8400B “AUTOSAL” ; Guildline Instruments Ltd.: S/N 62827) with an additional peristaltic-type intake pump (Ocean Scientific International, Ltd.). A pair of precision digital thermometers (Model 9540 ; Guildline Instruments Ltd.) were used. The thermometer monitored the ambient temperature and the other monitored a bath temperature.

The specifications of the AUTOSAL salinometer and thermometer are shown as follows ;

Salinometer (Model 8400B “AUTOSAL” ; Guildline Instruments Ltd.)
Measurement Range : 0.005 to 42 (PSU)
Accuracy : Better than ±0.002 (PSU) over 24 hours without re-standardization
Maximum Resolution : Better than ±0.0002 (PSU) at 35 (PSU)

Thermometer (Model 9540 ; Guildline Instruments Ltd.)

Measurement Range : -40 to +180 deg C
Resolution : 0.001
Limits of error ±deg C : 0.01 (24 hours @ 23 deg C ±1 deg C)
Repeatability : ±2 least significant digits

The measurement system was almost the same as Aoyama *et al*. (2002). The salinometer was operated in the air-conditioned ship's laboratory at a bath temperature of 24 deg C. The ambient temperature varied from approximately 21 deg C to 24 deg C, while the bath temperature was very stable and varied within +/- 0.002 deg C on rare occasion. The measurement for each sample was done with a double conductivity ratio and defined as the median of 31 readings of the salinometer. Data collection was started 10 seconds after filling the cell with the sample and it took about 15 seconds to collect 31 readings by a personal computer. Data were taken for the sixth and seventh filling of the cell. In the case of the difference between the double conductivity ratio of these two fillings being smaller than 0.00002, the average value of the double conductivity ratio was used to calculate the bottle salinity with the algorithm for the practical salinity scale, 1978 (UNESCO, 1981). If the difference was greater than or equal to 0.00003, an eighth filling of the cell was done. In the case of the difference between the double conductivity ratio of these two fillings being smaller than 0.00002, the average value of the double conductivity ratio was used to calculate the bottle salinity. The measurement was conducted in about 8 hours per day and the cell was cleaned with soap after the measurement of the day.

(4) Results

a. Standard Seawater

Standardization control of the salinometer was set to 453 and all measurements were done at this setting. The value of STANDBY was 5386 +/- 0001 and that of ZERO was 0.0+0000 or 0.0+0001. The conductivity ratio of IAPSO Standard Seawater batch P151 was 0.99997 (double conductivity ratio was 1.99994) and was used as the standard for salinity. 22 bottles of P151 were measured.

Fig.5.14-1 shows the history of the double conductivity ratio of the Standard Seawater batch P151. The average of the double conductivity ratio was 1.99995 and the standard deviation was 0.00001, which is equivalent to 0.0003 in salinity.

Fig.5.14-2 shows the history of the double conductivity ratio of the Standard Seawater batch P151 after correction. The average of the double conductivity ratio after correction was 1.99994 and the standard deviation was 0.00001, which is equivalent to 0.0002 in salinity.

The specifications of SSW used in this cruise are shown as follows ;

batch : P151
conductivity ratio : 0.99997
salinity : 34.999
Use By : 20th May 2012

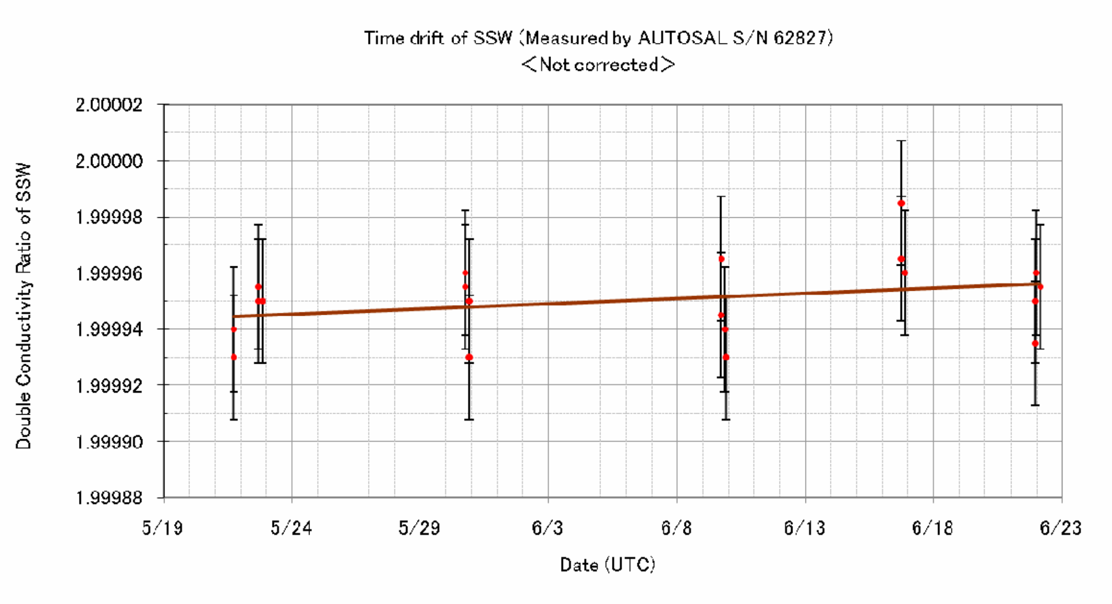

Fig. 5.14-1 History of double conductivity ratio for the Standard Seawater batch P151 (before correction)

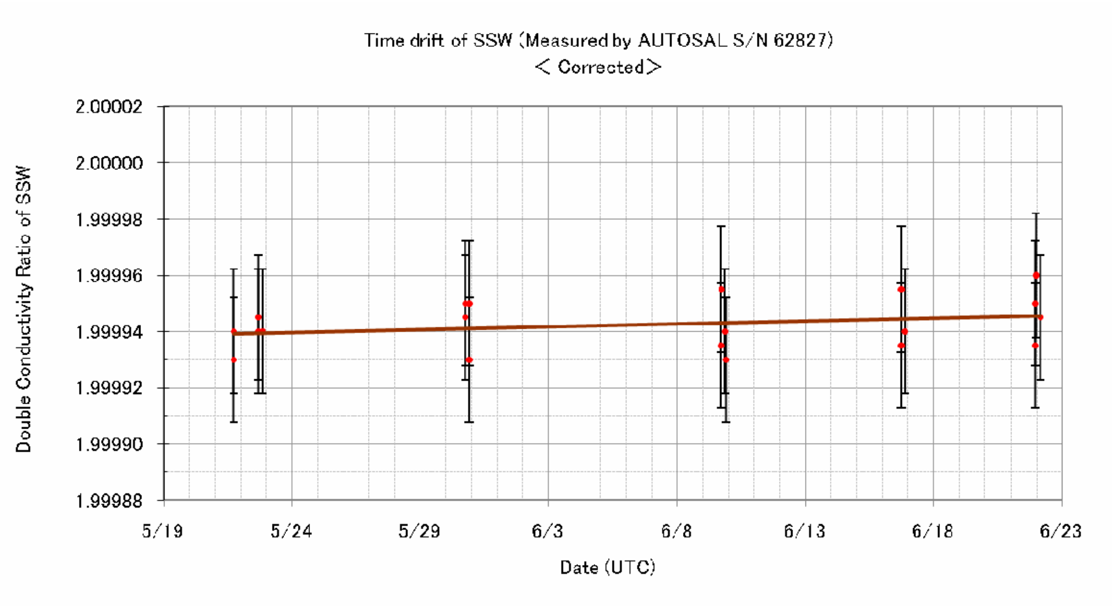

Fig. 5.14-2 History of double conductivity ratio for the Standard Seawater batch P151 (after correction)

b. Sub-Standard Seawater

Sub-standard seawater was made from deep-sea water filtered by a pore size of 0.45 micrometer and stored in a 20 liter container made of polyethylene and stirred for at least 24 hours before measuring. It was measured about every 8 samples in order to check for the possible sudden drifts of the salinometer.

c. Replicate Samples

We estimated the precision of this method using 72 pairs of replicate samples taken from the same Niskin bottle. The average and the standard deviation of absolute difference among 72 pairs of replicate samples were 0.0002 and 0.0002 in salinity, respectively.

(5) Data archive

These raw datasets will be submitted to JAMSTEC Data Management Office (DMO) and corrected datasets are available from Mirai Web site at http://www.jamstec.go.jp/mirai/.

(6) Reference

・Aoyama, M., T. Joyce, T. Kawano and Y. Takatsuki : Standard seawater comparison up to P129. Deep-Sea Research, I, Vol. 49, 1103～1114, 2002

・UNESCO : Tenth report of the Joint Panel on Oceanographic Tables and Standards. UNESCO Tech. Papers in Mar. Sci., 36, 25 pp., 1981

5.15 Dissolved Oxygen of Sampled Water

(1)Personal

Hiroyuki YAMADA	(JAMSTEC)	*Principal Investigator
Hironori SATO	(Marine Works Japan Co. Ltd)	*Operation Leader

(2)Objectives

Sea water was sampled at 500 dbar and the dissolved oxygen was measured by Winkler titration in order to calibrate the value measured by .the CTD system.

(3)Parameters

Dissolved Oxygen

(4)Instruments and Methods

(a)Reagents

Pickling Reagent I: Manganese chloride solution (3 mol/dm^3)
Pickling Reagent II: Sodium hydroxide (8 mol/dm^3) / sodium iodide solution (4 mol/dm^3)
Sulfuric acid solution (5 mol/dm^3)
Sodium thiosulfate (0.025 mol/dm^3)
Potassium iodate (0.001667 mol/dm^3)

(b)Instruments

Burette for sodium thiosulfate and potassium iodate;
APB-510 manufactured by Kyoto Electronic Co. Ltd. / 10 cm^3 of titration vessel
Detector and Software;
Automatic photometric titrator (DOT-01) manufactured by Kimoto Electronic Co. Ltd.

(5)Sampling

Following procedure is based on the WHP Operations and Methods (Dickson, 1996). Seawater samples were collected with Niskin bottle attached to the CTD-system. Seawater for oxygen measurement was transferred from Niskin sampler bottle to a volume calibrated flask (ca. 100 cm^3). Three times volume of the flask of seawater was overflowed. Temperature was measured by digital thermometer during the overflowing. Then two reagent solutions (Reagent I and II) of 0.5 cm^3 each were added immediately into the sample flask and the stopper was inserted carefully into the flask. The sample flask was then shaken vigorously to mix the contents and to disperse the precipitate finely throughout. After the precipitate has settled at least halfway down the flask, the flask was shaken again vigorously to disperse the precipitate. The sample flasks containing pickled samples were stored in a laboratory until they were titrated.

(6)Sample measurement

At least two hours after the re-shaking, the pickled samples were measured on board. A magnetic stirrer bar and 1 cm^3 sulfuric acid solution were added into the sample flask and stirring began. Samples were titrated by sodium thiosulfate solution which molarity was determined by potassium iodate solution. Temperature of sodium thiosulfate during titration was recorded by a digital thermometer. During this cruise, we measured dissolved oxygen concentration using 1 set of the titration apparatus. Dissolved oxygen concentration (μmol kg^{-1}) was calculated by sample temperature during seawater sampling, salinity of the sample, and titrated volume of sodium thiosulfate solution without the blank.

(7)Standardization and determination of the blank

Concentration of sodium thiosulfate titrant (ca. 0.025 mol/dm^3) was determined by potassium iodate solution. Pure potassium iodate was dried in an oven at 130^{o}C. 1.7835g potassium iodate weighed out accurately was dissolved in deionized water and diluted to final volume of 5 dm^3 in a calibrated volumetric flask (0.001667 mol/dm^3). 10 cm^3 of the standard potassium iodate solution was added to a flask using a calibrated dispenser. Then 90 cm^3 of deionized water, 1 cm^3 of sulfuric acid solution, and 0.5 cm^3 of pickling reagent solution II and I were added into the flask in order. Amount of sodium thiosulfate titrated gave the molarity of sodium thiosulfate titrant.

The blank from the presence of redox species apart from oxygen in the reagents was determined as follows. Firstly, 1 cm^3 of the standard potassium iodate solution was added to a flask using a calibrated dispenser. Then 100 cm^3 of deionized water, 1 cm^3 of sulfuric acid solution, and 0.5 cm^3 of pickling reagent solution II and I were added into the flask in order. Secondary, 2 cm^3 of the standard potassium iodate solution was added to a flask using a calibrated dispenser. Then 100 cm^3 of deionized water, 1 cm^3 of sulfuric acid solution, and 0.5 cm^3 of pickling reagent solution II and I were added into the flask in order. The blank was determined by difference between the first and second titrated volumes of the sodium thiosulfate.

Table5.15-1 Results of the standardization and the blank determinations during this cruise.

Date	KIO_3	$Na_2S_2O_3$	DOT-01(No.2)	
			E.P.	Blank
2010/5/7	20091214-02-08	20091207-4-1	3.957	-0.001
2010/5/7	CSK	20091207-4-1	3.959	-0.001
2010/5/15	20091214-02-09	20091207-4-1	3.962	0.000
2010/5/22	20091214-02-10	20091207-4-1	3.962	-0.001
2010/5/29	20091214-02-11	20091207-4-1	3.963	0.000
2010/5/29	20091215-03-01	20091207-4-1	3.962	-0.002
2010/6/5	20091215-03-02	20091207-4-1	3.961	0.000
2010/6/12	20091215-03-03	20091207-4-1	3.959	-0.001
2010/6/12	20091215-03-03	20091207-4-2	3.957	-0.001
2010/6/21	20091215-03-05	20091207-4-2	3.956	-0.001
2010/6/21	CSK	20091207-4-2	3.958	-0.001

(8)Repeatability of sample measurement

During this cruise we measured oxygen concentration in 144 seawater samples at 36 casts. Replicate samples were taken at every CTD casts. The standard deviation of the replicate measurement was 0.09 μmol kg^{-1} that was calculated by a procedure in Guide to best practices for ocean CO_2 measurements Chapter4 SOP23 Ver.3.0 (2007).

(9)Data archive

All data will be submitted to JAMSTEC Data Management Office (DMO).

(10)Reference

1. Dickson, A.G., Determination of dissolved oxygen in sea water by Winkler titration. (1996)
2. Dickson, A.G., Sabine, C.L. and Christian, J.R. (Eds.), Guide to best practices for ocean CO2 measurements. (2007)
3. Culberson, C.H., WHP Operations and Methods July-1991 “Dissolved Oxygen”, (1991)
4. Japan Meteorological Agency, Oceanographic research guidelines（Part 1）. (1999)
5. KIMOTO electric CO. LTD., Automatic photometric titrator DOT-01 Instruction manual

5.16 Observation of Photosynthetically Active Radiation

(1) Personnel

Ken FURUYA	(The University of Tokyo)	Principal Investigator	*not on board
Takako MASUDA	(The University of Tokyo)	Operation Leader	
Xin LIU	(The University of Tokyo)		
Taketoshi KODAMA	(The University of Tokyo)	* not on board	

(2) Objectives

Underwater light field was examined as ancillary data for biological observations, and to determine depths of seawater sampling described in the section 5.17.

(3) Methods

Vertical distribution of spectra of photosynthetically active radiation was profiled from the surface to the 100-m depth using a PRR-600 (Biospherical Instruments) every two days.

(4) Results

All the obtained data will be calibrated and analyzed after the cruise

(5) Data Archive

All the data obtained during the cruise will be submitted to the JAMSTEC Data Integration and Analyses Group within two years after the cruise.

5.17 Nutrients, N_2 fixation activity, primary productivity and abundance of phytoplankton

(1) Personnel

Ken FURUYA	(The University of Tokyo)	Principal Investigator	*not on board
Takako MASUDA	(The University of Tokyo)	Operation Leader	
Xin LIU	(The University of Tokyo)		
Taketoshi KODAMA	(The University of Tokyo)	* not on board	
Masanori ENOKI	(Marine Works Japan)		

(2) Objectives

The importance of nanoplanktonic cyanobacteria in N_2 fixation in the subtropical and tropical ocean is well recognized. However, our knowledge on temporal and spacial variations in N_2 fixation activity is still fragmentary. We conducted a time series observation and sampling for ca a month to examine temporal variations in N_2 fixation and related biological activities. Data obtained during this cruise will be analyzed to clarify environmental control of N_2 fixation and population dynamics of diazotrophs and other phytoplankton.

(3) Methods

Temporal variations of nutrients, N_2 fixation and phytoplankton assemblages at the Station 09M

Samples for nutrients, *nifH* gene, *amoA* gene, phytoplankton abundance and pigments analysis were collected every day from 16 May to 20 June by a bucket and Niskin samplers upto 500 m depth. In addition, samples for N_2 fixation, primary production and NO_3^- assimilation, and SPM were collected every two days, and samples for nitrification were collected every four days.

Samples for nutrient analysis were frozen immediately for later analysis on land. Aliquots of the samples for chlorophyll *a* concentration were analyzed by a fluorometer on board. Subsamples for phytoplankton abundance were fixed by 1% glutarualdehyde and frozen immediately or 0.6% Lugol solution for later analysis on land. Subsamples for pigments analysis, *nifH* and *amoA* genes abundance, and SPM were filtered by a GF/F or Durapore filter and frozen immediately until later analysis on board.

N_2 fixation and primary production were determined using a dual isotopic technique (^{13}C-^{15}N). Duplicate samples were poured into 4 L polycarbonate bottles and spiked with 0.2 mM of $H^{13}CO_3^-$ and 2 ml of $^{15}N_2$. For nitrate assimilation and nitrification experiments, duplicate samples were respectively collected 2 L polycarbonate bottles and spike with 10 nM of $^{15}NO_3^-$ and with 10 nM of $^{15}NH_4^+$. Then, samples were placed in the on-deck incubator under the light corresponding to the sampling depth. Incubations were terminated by filtration onto precombusted GF/F filters with gentle vacuum pressure (<200 mmHg). After filtration, filters were stored in a freezer. For the nitrification experiments, filtrates were also collected to be determined the amount of $^{15}NO_3^-$ formed in $^{15}NH_4^+$ enriched samples during the incubation. The filtrates were recovered in plastic bottles and poisoned with 0.2 ml saturated $HgCl_2$.

(4) Results

All the obtained data and samples will be calibrated and analyzed after the cruise

(5) Data Archive

All the data and list of the samples obtained during and after the cruise will be submitted to the JAMSTEC Data Integration and Analyses Group within two years after the cruise.

5.18 Argo Floats

(1) Personnel

Hiroyuki YAMADA	(JAMSTEC)	Principal Investigator	
Toshio SUGA	(JAMSTEC / Tohoku University)		* not on board
Shigeki HOSODA	(JAMSTEC)		* not on board
Ken'ichi KAYAYAMA	(Marine Works Japan)	Technical Staff	
Kanako SATO	(JAMSTEC)	Technical Staff	* not on board
Mizue HIRANO	(JAMSTEC)	Technical Staff	* not on board

(2) Objective

The objective is to measure the vertical profiles of sea-water temperature and salinity for investigating oceanic mixed layer structure and tropical air-sea interaction.

(3) Method

Seven NEMO-type Argo floats were deployed in an area between 6^{o}N and 17^{o}N and between 133.5^{o}E and 142.5^{o}E (see Table 5.18.1 and Fig. 5.18.1). These floats measure the vertical profiles of sea-water temperature and salinity above 500db every 24 hours. They use the Iridium transmitter to send observational data via satellite. Although two Provor-type Argo floats with Argos-type transmitter were also prepared, the deployment was canceled due to mechanical problems.

(4) Results

The vertical profiles of sea-water temperature and salinity, measured by NEMO-120 float near 11.5°N, 140.5°E are shown in Fig.5.18.2. These profiles are marked by a warming of the surface layer (0-50 dbar) and an increase of salinity in the subsurface layer (150-200 dbar).

(5) Data archive

The real-time data are provided officially via the Web site of Global Data Assembly Center (GDAC: http://www.usgodae.org/argo/argo.html, http://www.coriolis.eu.org/) in netCDF format The Argo group in JAMTEC (http://www.jamstec.go.jp/ARGO/J-ARGO/) also provide the real-time quality controlled data in ASCII format.

Table 5.18.1 Deployments of the floats

Type	Serial Number	Date (YYY/MM/DD)	Time (UTC)	Latitude	Longitude	Type
NEMO	113	2010/05/11	05:03	8.009N	133.505E	Iridium
NEMO	114	2010/05/14	00:09	6.001N	133.488E	Iridium
NEMO	115	2010/05/09	00:05	8.003N	142.003E	Iridium
NEMO	116	2010/05/06	23:39	17.000N	139.501E	Iridium
NEMO	118	2010/05/05	23:51	15.003N	142.492E	Iridium
NEMO	119	2010/05/09	23:32	8.003N	139.501E	Iridium
NEMO	120	2010/05/08	02:45	11.003N	139.491E	Iridium
Provor	09010	Not deployed	N/A	N/A	N/A	Argos
Provor	09015	Not deployed	N/A	N/A	N/A	Argos

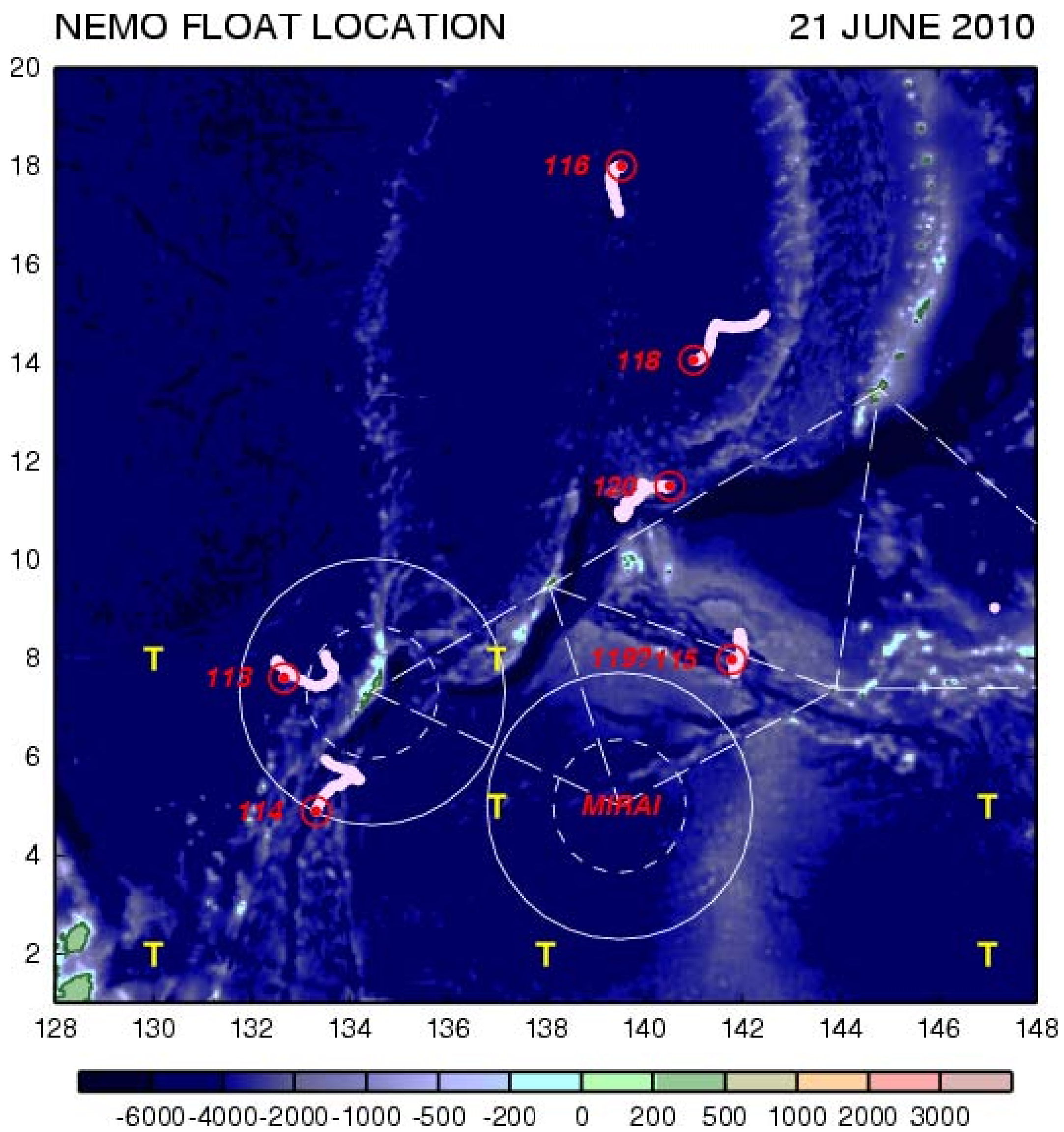

Fig. 5.18-1: The track of NEMO-type Argo floats until 21 June 2010. The latest position is marked by a red open circle with a dot. Note that NEMO-119 float lost GPS signal after the deployment and its location is not known. The labels "T" mean the location of TRITON mooring buoys while white open circles indicate the observational area of a Doppler radar at Palau and that on board R/V Mirai.

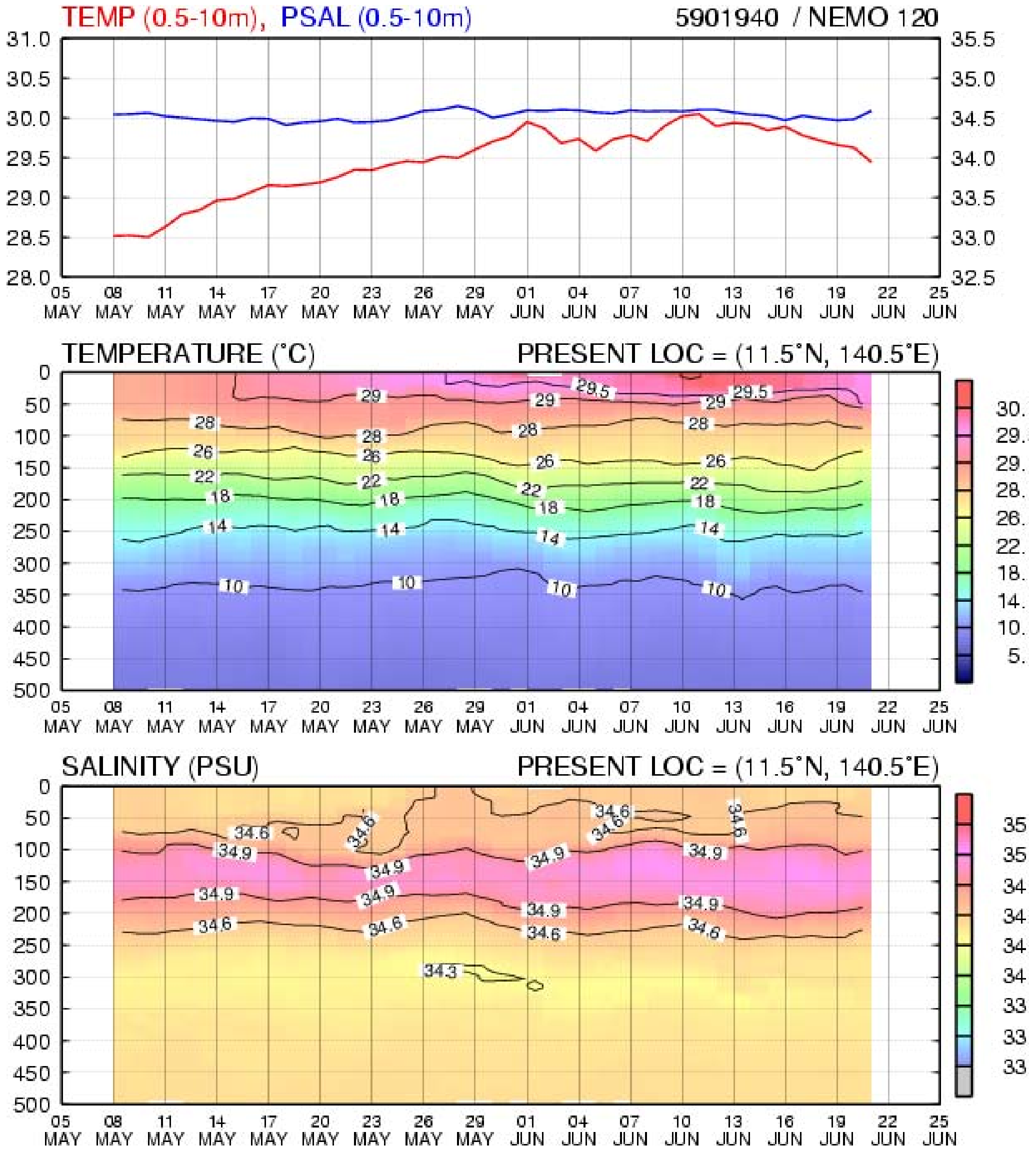

Fig. 5.18-2: Time-depth cross sections of sea-water temperature (top) and salinity (bottom), observed by NEMO-120 float that was deployed on 8 May near 11°N, 139.5°E.

5.19 Micro Structure Profiler for the Ocean

(1) Personnel

Masaki KATSUMATA	(JAMSTEC)	*Principal Investigator
Biao GENG	(JAMSTEC)	
Hiroyuki YAMADA	(JAMSTEC)	
Souichiro SUEYOSHI	(Global Ocean Development Inc.; GODI)	*Operation Leader
Harumi OTA	(GODI)	
Asuka DOI	(GODI)	
Ryo OHYAMA	(Mirai Crew)	

(2) Objectives

To obtain oceanic vertical profiles of the dissipation rate of turbulent kinematic energy, dissipation rate of temperature variance, turbulent mixing rate of substances, etc.

(3) Methods

The instrument in this observation consists of sensor unit “TurboMAP-L” (manufactured by JFE Advantech Inc., serial no. 34) and the software “TMtools” (ver. 3.04C) on PC to monitor, record and process the data. The probes on the TurboMAP sensor unit are as follows:

- Vertical shear of the horizontal current speed (two sensors, 512 Hz)
- Fast thermistor temperature (512Hz)
- Slow response temperature (64Hz)
- Conductivity (64Hz)
- Pressure (64Hz)
- Acceleration in X, Y and Z dimensions (256Hz for horizontal, 64Hz for vertical)
- Fluorescence (256Hz)
- Turbidity (256Hz)

These parameters were obtained during the sensor descends without artificial accelerations (i.e. “free fall”). The obtained data was monitored and stored in the PC on the vessel in real-time.

In this cruise, the cable connecting the PC and the sensor was being deployed until the sensor reached 300-m in depth, to obtain the profile up to 300 m in minimum. Without further deployment of the cable, the data was recorded until the sensor stopped its free-fall (i.e. falling speed start decreasing).

To obtain the temporal variation of the vertical profiles, observation at (5N, 139.5E) was carried out every 12 hours from 00UTC on May 15 to 12UTC on June 20. In addition, two 3-day periods were dedicated as 3-hourly observation to inspect the short-term variation (e.g. diurnal variation). Several simultaneous observations to the CTDO profiling (see Section 5.13) were also done before arriving the stationary observation point. As in Table 5.19-1, 118 profiles were obtained in total during the present cruise.

(4) Results

Figure 5.19-1 is the time-depth cross section of the dissipation rate of kinematic energy (epsilon), which is calculated by “TMtools ver. 3.03C”, during the observation period at (5N, 139.5E). The high epsilon value could be found continuously in the mixed layer. Around 100m depth, high epsilon eventually appeared around June 8th, when the high-salinity / low-dissolved-oxygen water around 150m depth retreats. The further detailed analyses will be in near future.

(5) Data archive

The raw datasets will be submitted to, archived at and will be available at JAMSTEC Data Integration and Analyses Group.

Table 5.19-1: Log for the MSP profiling.

No.	Lon	Lat	Date and Time (YYYY/MM/DD hh:mm)		Max Depth	Wire Length
			Start Recording Data	Stop Recording Data		
1	142-29E	15-00N	2010/05/06 23:21	2010/05/06 23:33	395	520
2	139-30E	17-00N	2010/05/07 23:08	2010/05/06 23:21	445	495
3	139-29E	11-00N	2010/05/08 02:19	2010/05/08 02:31	367	485
4	142-00E	08-00N	2010/05/09 23:39	2010/05/09 23:39	391	520
5	139-29E	08-00N	2010/05/10 23:03	2010/05/10 23:16	441	460
6	133-30E	08-00N	2010/05/11 04:35	2010/05/11 04:46	333	470
7	133-30E	06-00N	2010/05/14 23:44	2010/05/14 23:55	318	520
8	133-30E	05-01N	2010/05/14 05:33	2010/05/14 05:45	307	529
9	139-30E	05-00N	2010/05/16 00:28	2010/05/16 00:40	393	520
10	139-30E	05-00N	2010/05/16 12:11	2010/05/16 12:24	405	465
11	139-30E	05-00N	2010/05/17 00:29	2010/05/17 00:41	403	460
12	139-30E	04-59N	2010/05/17 12:10	2010/05/17 12:22	395	425
13	139-30E	05-00N	2010/05/18 00:25	2010/05/18 00:37	407	480
14	139-30E	05-00N	2010/05/18 12:13	2010/05/18 12:25	396	425
15	139-30E	05-00N	2010/05/19 00:33	2010/05/19 00:43	375	490
16	139-30E	05-00N	2010/05/19 12:11	2010/05/19 12:22	366	455
17	139-30E	05-00N	2010/05/20 00:28	2010/05/20 00:40	391	470
18	139-30E	05-00N	2010/05/20 12:07	2010/05/20 12:19	377	460
19	139-30E	05-00N	2010/05/21 00:33	2010/05/21 00:43	339	500
20	139-30E	05-00N	2010/05/21 12:14	2010/05/21 12:25	343	410
21	139-30E	05-00N	2010/05/22 00:29	2010/05/22 00:41	451	495
22	139-30E	05-00N	2010/05/22 12:12	2010/05/22 12:22	340	370
23	139-30E	05-00N	2010/05/23 00:38	2010/05/23 00:50	397	480
24	139-30E	05-00N	2010/05/23 12:11	2010/05/23 00:00	341	450
25	139-30E	05-00N	2010/05/24 00:32	2010/05/24 00:49	427	495
26	139-30E	05-00N	2010/05/24 03:11	2010/05/24 03:22	379	498
27	139-30E	05-00N	2010/05/24 06:11	2010/05/24 06:23	409	495
28	139-30E	05-00N	2010/05/24 09:15	2010/05/24 09:26	338	490
29	139-30E	05-00N	2010/05/24 12:10	2010/05/24 12:21	354	480
30	139-30E	05-00N	2010/05/24 15:13	2010/05/24 15:24	379	495
31	139-30E	05-00N	2010/05/24 18:12	2010/05/24 18:23	340	440
32	139-30E	05-00N	2010/05/24 21:15	2010/05/24 21:26	375	510
33	139-30E	05-00N	2010/05/25 00:29	2010/05/25 00:41	424	500
34	139-30E	05-00N	2010/05/25 03:08	2010/05/25 03:19	373	510
35	139-30E	05-00N	2010/05/25 06:12	2010/05/25 06:24	422	510
36	139-30E	05-00N	2010/05/25 09:13	2010/05/25 09:25	398	510
37	139-30E	05-00N	2010/05/25 12:10	2010/05/25 12:22	381	450
38	139-30E	05-00N	2010/05/25 15:14	2010/05/25 15:25	345	430
39	139-30E	05-00N	2010/05/25 18:13	2010/05/25 18:23	352	430

40	139-30E	05-00N	2010/05/25 21:17	2010/05/25 21:29	409	470
41	139-30E	05-00N	2010/05/26 00:28	2010/05/26 00:37	344	495
42	139-30E	05-00N	2010/05/26 03:11	2010/05/26 03:22	392	495
43	139-30E	05-00N	2010/05/26 06:11	2010/05/26 06:20	344	500
44	139-30E	05-00N	2010/05/26 09:14	2010/05/26 09:25	328	480
45	139-30E	05-00N	2010/05/26 12:10	2010/05/26 12:20	324	530
46	139-30E	05-00N	2010/05/26 15:11	2010/05/26 15:22	343	420
47	139-30E	05-00N	2010/05/26 18:13	2010/05/26 18:23	339	440
48	139-30E	05-00N	2010/05/26 21:13	2010/05/26 21:23	336	450
49	139-30E	05-00N	2010/05/27 00:13	2010/05:27 00:25	390	480
50	139-30E	05-00N	2010/05/27 12:08	2010/05/27 12:19	338	510
51	139-30E	05-00N	2010/05/28 00:29	2010/05/28 00:40	366	480
52	139-30E	05-00N	2010/05/28 12:09	2010/05/28 12:19	306	440
53	139-30E	05-00N	2010/05/29 00:41	2010/05/29 00:52	383	470
54	139-30E	05-00N	2010/05/29 12:10	2010/05/29 12:22	371	430
55	139-30E	05-00N	2010/05/30 00:28	2010/05/30 00:39	387	480
56	139-30E	05-00N	2010/05/30 12:10	2010/05/30 12:21	356	450
57	139-30E	05-00N	2010/05/31 00:28	2010/05/31 00:39	368	500
58	139-30E	05-00N	2010/05/31 12:09	2010/05/31 12:19	338	460
59	139-30E	05-00N	2010/06/01 00:26	2010/06/01 00:36	348	450
60	139-30E	05-00N	2010/06/01 12:08	2010/06/01 12:08	328	470
61	139-30E	05-00N	2010/06/02 00:15	2010/06/02 00:25	339	450
62	139-30E	05-00N	2010/06/02 12:07	2010/06/02 12:19	415	480
63	139-30E	05-00N	2010/06/03 00:29	2010/06/03 00:40	378	470
64	139-30E	05-00N	2010/06/03 12:07	2010/06/03 12:17	344	440
65	139-30E	05-00N	2010/06/04 00:29	2010/06/04 00:39	358	490
66	139-30E	05-00N	2010/06/04 12:08	2010/06/04 12:19	360	480
67	139-30E	05-00N	2010/06/05 00:25	2010/06/05 00:37	397	470
68	139-30E	05-00N	2010/06/05 12:08	2010/06/05 12:19	384	440
69	139-30E	05-00N	2010/06/06 00:29	2010/06/06 00:40	381	480
70	139-30E	05-00N	2010/06/06 12:15	2010/06/06 12:26	360	460
71	139-30E	05-00N	2010/06/07 00:30	2010/06/07 00:41	348	515
72	139-30E	05-00N	2010/06/07 03:07	2010/06/07 03:19	356	495
73	139-30E	05-00N	2010/06/07 06:09	2010/06/07 06:20	359	510
74	139-30E	05-00N	2010/06/07 09:08	2010/06/07 09:22	336	495
75	139-30E	05-00N	2010/06/07 15:07	2010/06/07 15:22	394	510
76	139-30E	05-00N	2010/06/07 18:13	2010/06/07 18:29	453	490
77	139-30E	05-00N	2010/06/07 21:10	2010/06/07 21:23	370	450
78	139-30E	05-00N	2010/06/08 00:13	2010/06/08 00:25	380	470
79	139-30E	05-00N	2010/06/08 03:06	2010/06/08 03:18	359	460
80	139-30E	05-00N	2010/06/08 06:07	2010/06/08 06:19	342	470
81	139-30E	05-00N	2010/06/08 09:10	2010/06/08 09:22	346	480
82	139-30E	05-00N	2010/06/08 12:06	2010/06/08 12:18	325	480
83	139-30E	05-00N	2010/06/08 15:07	2010/06/08 15:19	354	480
84	139-30E	05-00N	2010/06/08 18:07	2010/06/08 18:21	428	470
85	139-30E	05-00N	2010/06/08 21:14	2010/06/08 21:28	404	460
86	139-30E	05-00N	2010/06/09 00:26	2010/06/09 00:38	402	480
87	139-30E	05-00N	2010/06/09 03:10	2010/06/09 03:20	363	470
88	139-30E	05-00N	2010/06/09 05:52	2010/06/09 06:05	364	470

89	139-30E	05-00N	2010/06/09 09:09	2010/06/09 09:22	357	470
90	139-30E	05-00N	2010/06/09 12:05	2010/06/09 12:16	350	465
91	139-30E	05-00N	2010/06/09 15:07	2010/06/09 15:18	346	410
92	139-30E	05-00N	2010/06/09 18:12	2010/06/09 18:22	384	440
93	139-30E	05-00N	2010/06/09 21:10	2010/06/09 21:24	400	430
94	139-30E	05-00N	2010/06/10 00:24	2010/06/10 00:37	398	470
95	139-30E	05-00N	2010/06/10 12:06	2010/06/10 12:18	368	520
96	139-30E	05-00N	2010/06/11 00:26	2010/06/11 00:39	414	480
97	139-30E	05-00N	2010/06/11 12:05	2010/06/11 12:18	379	470
98	139-30E	05-00N	2010/06/12 00:26	2010/06/12 00:38	403	480
99	139-30E	05-00N	2010/06/12 12:09	2010/06/12 12:23	421	520
100	139-30E	05-00N	2010/06/13 00:26	2010/06/13 00:39	413	460
101	139-30E	05-00N	2010/06/13 12:08	2010/06/13 12:22	428	470
102	139-30E	05-00N	2010/06/14 00:13	2010/06/14 00:25	374	430
103	139-30E	05-00N	2010/06/14 12:07	2010/06/14 12:22	451	510
104	139-30E	05-00N	2010/06/15 00:28	2010/06/15 00:43	443	500
105	139-30E	05-00N	2010/06/15 12:07	2010/06/15 12:20	388	440
106	139-30E	05-00N	2010/06/16 00:30	2010/06/16 00:40	360	410
107	139-30E	05-00N	2010/06/16 12:07	2010/06/16 12:20	380	430
108	139-30E	05-00N	2010/06/17 00:29	2010/06/17 00:43	371	430
109	139-30E	05-00N	2010/06/17 12:06	2010/06/17 12:20	415	450
110	139-30E	05-00N	2010/06/18 00:27	2010/06/18 00:40	392	510
111	139-30E	05-00N	2010/06/18 12:08	2010/06/18 12:20	347	380
112	139-30E	05-00N	2010/06/19 00:28	2010/06/19 00:42	400	470
113	139-30E	05-00N	2010/06/19 12:08	2010/06/18 12:20	342	500
114	139-30E	05-00N	2010/06/20 00:15	2010/06/20 00:28	407	495
115	139-30E	05-00N	2010/06/20 00:39	2010/06/20 00:50	379	460
116	139-30E	05-00N	2010/06/20 00:59	2010/06/20 01:09	329	460
117	139-29E	05-00N	2010/06/20 01:18	2010/06/20 01:29	339	530
118	139-30E	05-00N	2010/06/20 12:08	2010/06/20 12:23	419	480

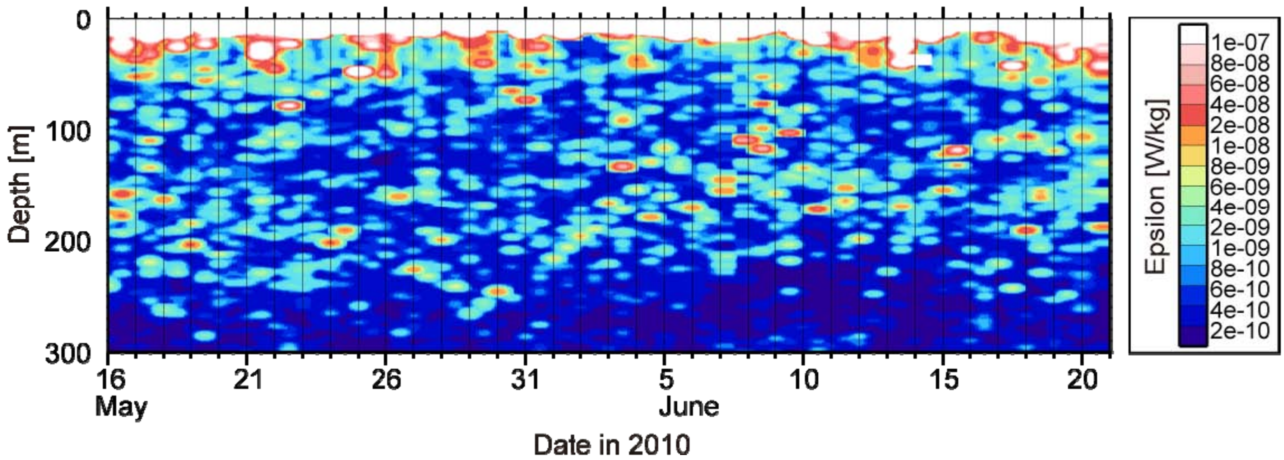

Fig.5.19-1: Time-depth cross section of the dissipation ratio of the kinematic energy during the stationary observation period.

5.20 Shipboard ADCP

(1) Personnel

Hiroyuki YAMADA	(JAMSTEC)	Principal Investigator
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Harumi OTA	(GODI)	
Asuka DOI	(GODI)	
Ryo OHYAMA	(MIRAI Crew)	

(2) Objective

To obtain continuous measurement of the current profile along the ship's track.

(3) Methods

Upper ocean current measurements were made in MR10-03 cruise, using the hull-mounted Acoustic Doppler Current Profiler (ADCP) system. For most of its operation the instrument was configured for water-tracking mode. Bottom-tracking mode, interleaved bottom-ping with water-ping, was made to get the calibration data for evaluating transducer misalignment angle. The system consists of following components;

1) R/V MIRAI has installed the Ocean Surveyor for vessel-mount (acoustic frequency 75 kHz; Teledyne RD Instruments). It has a phased-array transducer with single ceramic assembly and creates 4 acoustic beams electronically. We mounted the transducer head rotated to a ship-relative angle of 45 degrees azimuth from the keel
2) For heading source, we use ship's gyro compass (Tokimec, Japan), continuously providing heading to the ADCP system directory. Additionally, we have Inertial Navigation System (INS) which provide high-precision heading, attitude information, pitch and roll, are stored in ".N2R" data files with a time stamp.
3) DGPS system (Trimble SPS751 & StarFixXP) providing position fixes.
4) We used VmDas version 1.4.2 (TRD Instruments) for data acquisition.
5) To synchronize time stamp of ping with GPS time, the clock of the logging computer is adjusted to GPS time every 1 minute
6) We have placed ethylene glycol into the fresh water to prevent freezing in the sea chest.
7) The sound speed at the transducer does affect the vertical bin mapping and vertical velocity measurement, is calculated from temperature, salinity (constant value; 35.0 psu) and depth (6.5 m; transducer depth) by equation in Medwin (1975).

Data was configured for 16-m intervals starting 23-m below the surface. Every ping was recorded as raw ensemble data (.ENR). Also, 60 seconds and 300 seconds averaged data were recorded as short term average (.STA) and long term average (.LTA) data, respectively. Major parameters for the measurement (Direct Command) are shown in Table 5.20-1.

(4) Preliminary results

Fig.5.20-1～5.20-3 shows time series plot of current U･V vector during stationary observation.

(5) Data archive

These data obtained in this cruise will be submitted to the Data Integration and Analysis Group (DIAG) of JAMSTEC, and will be opened to the public via JAMSTEC home page.

(6) Remarks

1) Following periods, data acquisition was suspended in either territorial waters or exclusive economic zones.
   04:00UTC 05th May to 06:40UTC 05th May 2010 (Guam, U.S.A.)
   12:00UTC 08th May to 05:30UTC 09th May 2010 (Federated States of Micronesia)
   22:58UTC 11th May to 07:50UTC 13th May 2010 (Republic of Palau)

Table 5.20-1: Major parameters

Bottom-Track Commands	
BP = 001	Pings per Ensemble (almost less than 1000m depth)
Environmental Sensor Commands	
EA = +04500	Heading Alignment (1/100 deg)
EB = +00000	Heading Bias (1/100 deg)
ED = 00065	Transducer Depth (0 - 65535 dm)
EF = +001	Pitch/Roll Divisor/Multiplier (pos/neg) [1/99 - 99]
EH = 00000	Heading (1/100 deg)
ES = 35	Salinity (0-40 pp thousand)
EX = 00000	Coord Transform (Xform:Type; Tilts; 3Bm; Map)
EZ = 10200010	Sensor Source (C; D; H; P; R; S; T; U)
	C (1): Sound velocity calculates using ED, ES, ET (temp.)
	D (0): Manual ED
	H (2): External synchro
	P (0), R (0): Manual EP, ER (0 degree)
	S (0): Manual ES
	T (1): Internal transducer sensor
	U (0): Manual EU
Timing Commands	
TE = 00:00:02.00	Time per Ensemble (hrs:min:sec.sec/100)
TP = 00:02.00	Time per Ping (min:sec.sec/100)
Water-Track Commands	
WA = 255	False Target Threshold (Max) (0-255 count)
WB = 1	Mode 1 Bandwidth Control (0=Wid, 1=Med, 2=Nar)
WC = 120	Low Correlation Threshold (0-255)
WD = 111 100 000	Data Out (V; C; A; PG; St; Vsum; Vsum^2;#G;P0)
WE = 1000	Error Velocity Threshold (0-5000 mm/s)
WF = 0800	Blank After Transmit (cm)
WG = 001	Percent Good Minimum (0-100%)
WI = 0	Clip Data Past Bottom (0 = OFF, 1 = ON)
WJ = 1	Rcvr Gain Select (0 = Low, 1 = High)
WM = 1	Profiling Mode (1-8)
WN = 40	Number of depth cells (1-128)
WP = 00001	Pings per Ensemble (0-16384)
WS= 1600	Depth Cell Size (cm)
WT = 000	Transmit Length (cm) [0 = Bin Length]
WV = 0390	Mode 1 Ambiguity Velocity (cm/s radial)

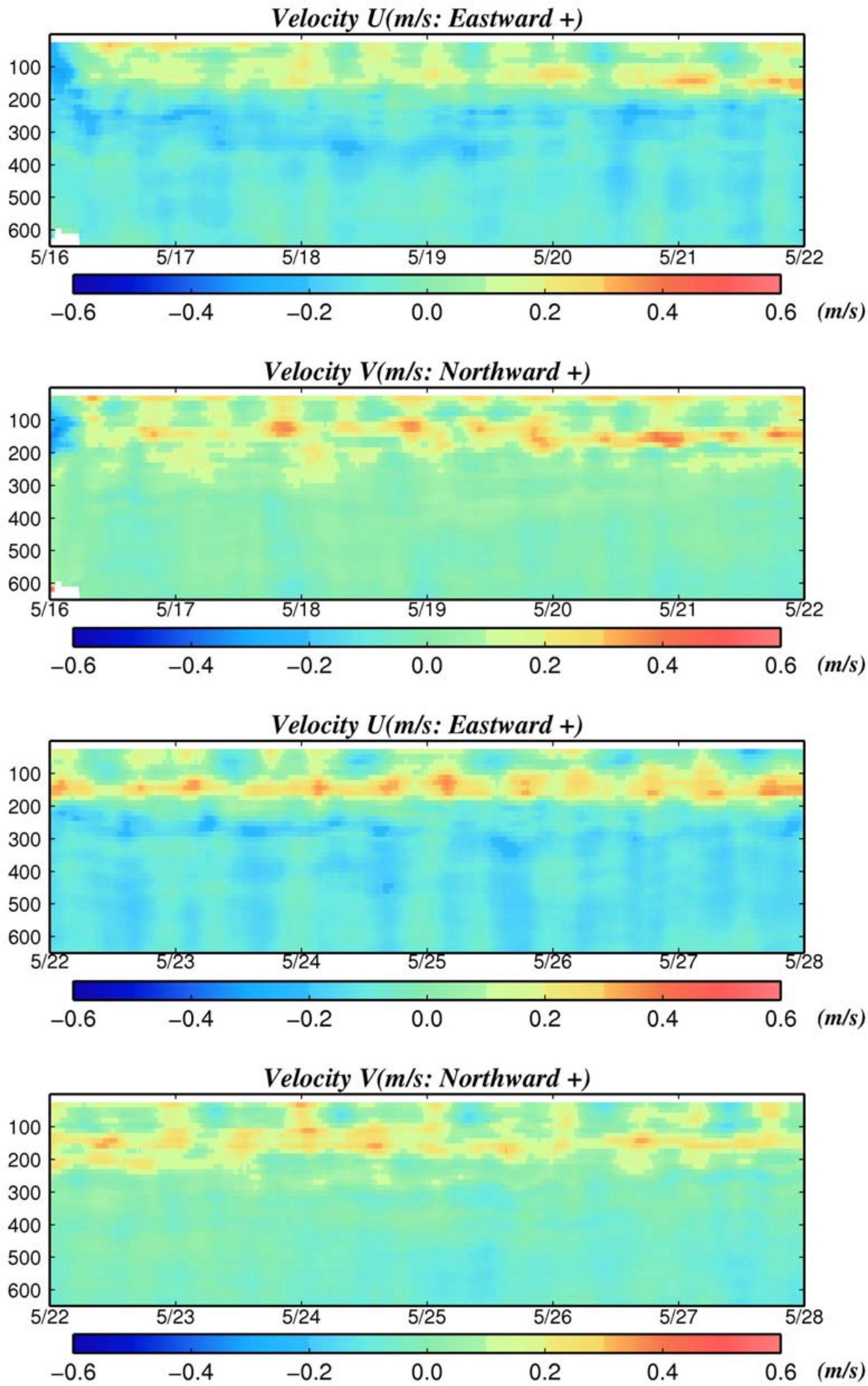

Fig. 5.20-1: Time series plot of Current U, V vector during Stationary Observation (From May 16 to May 28).

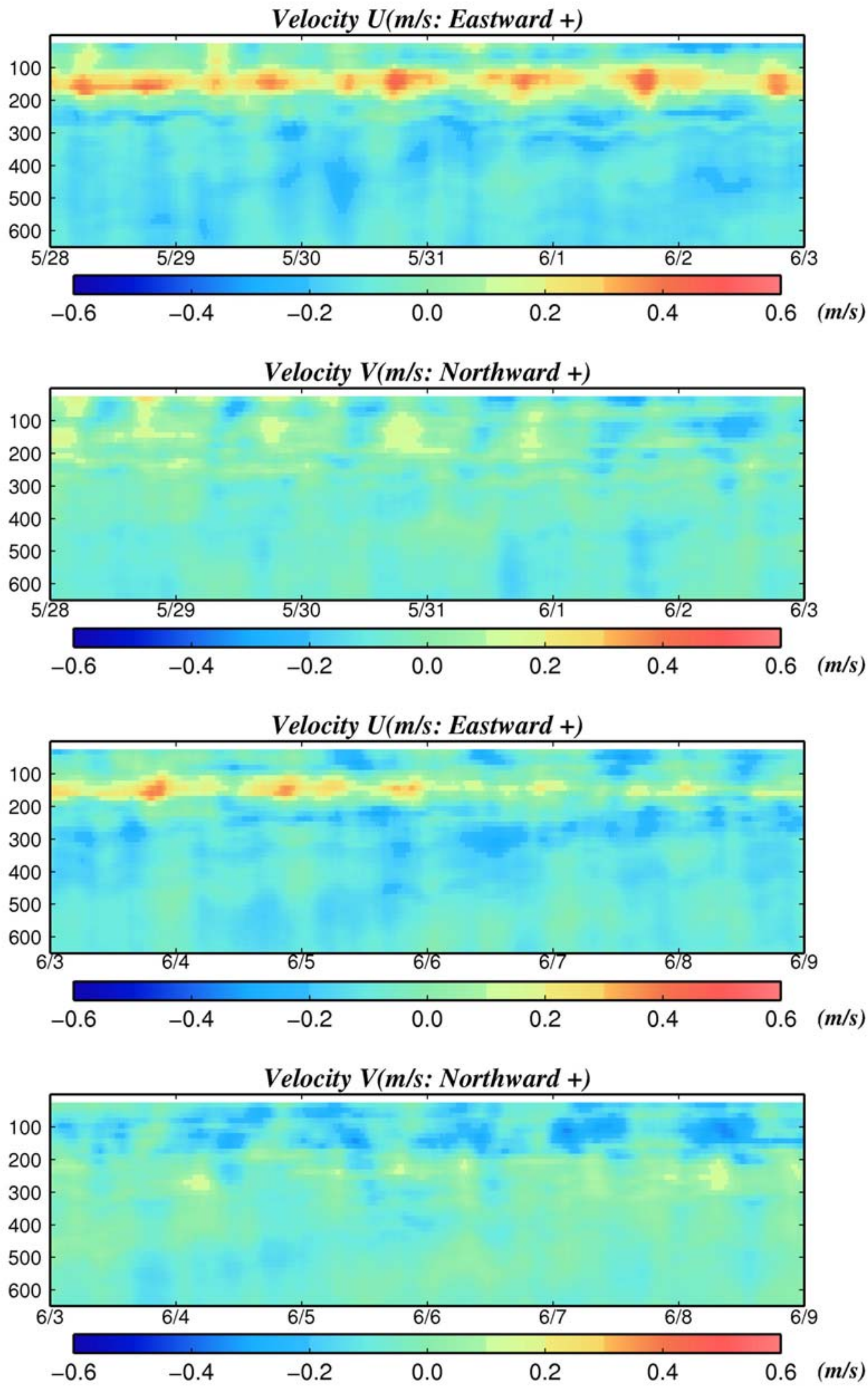

Fig. 5.20-2: Time series plot of Current U, V vector during Stationary Observation (From May 28 to June 9).

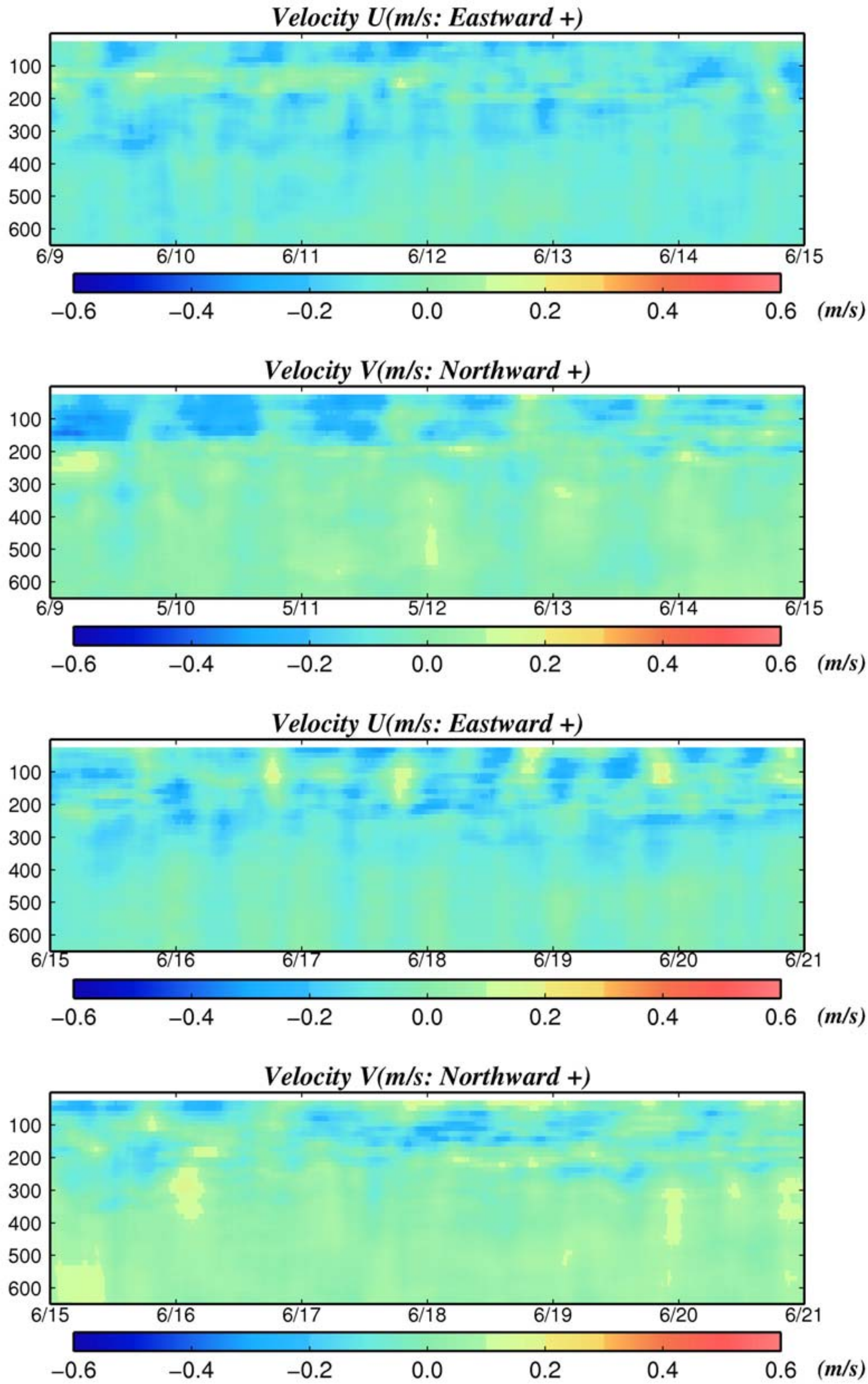

Fig. 5.20-3: Time series plot of Current U, V vector during Stationary Observation (From June 9 to June 21).

5.21 Heat-tolerance and super cooling point of the oceanic sea skaters of *Halobates* (Heteroptera: Gerridae)

(1) Personnel

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Koki IYOTA	(Kochi University)	
Yuki OSUMI	((Kochi University)	
Takero SEKIMOTO	((Kochi University)	

(2) Objectives

Many great voyages were launched to explore the oceans and what lies beyond, because they have always held a great fascination to us. A great variety of marine organisms were collected and describe during these voyages, but insects appear to have received little attention (Andersen & Chen, 2004). Although they are the most abundant animals on land, insects are relatively rare in marine environments (Cheng, 1985). However, a few thousand insect species belonging to more than 20 orders are considered to be marine (Cheng & Frank, 1993; Cheng, 2003). The majority of marine insects belong to the Coleoptera, Hemiptera, and Diptera, and they can be found in various marine habitats. However, the only insects to live in the open ocean are members of the genus *Halobates*, commonly known as sea-skaters. They belong to the family Gerridae (Heteroptera), which comprises the common pond-skaters or water-striders. Unlike most of its freshwater relatives, the genus *Halobates* is almost exclusively marine. Adults are small, measuring only about 0.5 cm in body length, but they have rather long legs and may have a leg span of 1.5 cm or more except for a new species, *Halobates megamoomario*. This new species which has very long boy length of 0.9 cm and large mid-leg span of 3.2 cm has been newly and recently collected in the tropical Pacific Ocean during the cruise, MR-06-05-Leg 3, and described (Harada et al., submitted). They are totally wingless at all stages of their life cycle and are confined to the air-sea interface, being an integral member of the pleuston community (Cheng, 1985). One may wonder how much tiny insects have managed to live in the open sea, battling waves and storms. In life, sea-skaters appear silvery. On calm days ocean-going scientists have probably seen them as shiny spiders skating over the sea surface. It is not known whether ancient mariners ever saw them, and no mention of their presence has been found in the logs of Christopher Columbus'S (1451-1506) ships or other ships that sailed to and from the New World (Andersen & Cheng, 2004).

Forty-seven species of *Halobates* are now known (Andersen & Cheng, 2004; Harada *et al.*, submitted). Six are oceanic and are widely distributed in the Pacific, Atlantic and the Indian Oceans. The remaining species occur in near-shore areas of the tropical seas associated with mangrove or other marine plants. Many are endemic to islands or island groups (Cheng, 1989).

The only insects that inhabit the open sea area are seven species of sea skaters: *Halobates micans, H.*

sericeus, H. germanus, H. splendens, H. sobrinus (Cheng, 1985) and new two species of *H. megamoomario* and *H. moomario* under description (Harada *et al.*, submitted). Three species, *Halobates sericeus*, *H. micans* and *H. germanus* inhabit tropical and temperate areas of the Pacific Ocean in the northern hemisphere, including The Kuroshio Current and the East China Sea (Andersen & Polhemus, 1976, Cheng, 1985). *Halobates sericeus, H. micans and H germanus* are reported from latitudes of 13ºN-40ºN, 0ºN-35ºNand 0ºN-37ºN, respectively, in the Pacific Ocean (Miyamoto & Senta,,1960; Andersen & Polhemus, 1976; Ikawa *et al.*, 2002). However, this information was collected on different cruises and in different times of the years. There have been several ecological studies based on samples collected in a specific area in a particular season during the six cruises of R/V HAKUHO-MARU: KH-02-01, KH-06-02, TANSEI-MARU: KT-07-19, KT-08-23 and R/V MIRAI: MR-06-05-Leg 3, MR-08-02.

During one cruise, KH-02-01, one sea skater species, *Halobates sericeus,* was collected at 18 locations in the East China Sea area (27°10' N- 33°24' N, 124º57' E - 129º30' E) (Harada, 2005), and *H. micans* and/or *H. germanus* at only 8 locations in the area south of 29° 47'N, where water temperatures were more than 25℃. At three locations, where the water temperature was less than 23℃, neither *H. micans* nor *H. germanus* were caught.

14˚30'N, *Halobates micans* were caught at 6 of 7 locations, while *H.germanus* and *H. sericeus* were caught at only 3 and 1 location(s), respectively (Harada *et al,* 2006). However, at 15˚00'N or northern area, *H. germanus* were caught at 14 of 19 locations, whereas *H. micans* and *H. cericeus* were caught at only 8 and 6 locations, respectively (Harada *et al*, 2006).

In the cruise, MR-06-05-Leg 3, larvae of both *H. micans* and *H. germanus* were very abundant at 6º N, whereas adults of *H. germanus* alone were completely dominant at 2º N on the longitudinal line of 130ºE. On the longitudinal line of 138ºE, larvae and adults of *H. micans* alone were dominant at points of 5 º and 8ºN, while adults of *H. germanus* were abundant between 0º and 2ºN. At the two stations of St. 37 (6º N, 130º E) and St. 52 (5º N, 138º E), relatively great number of larvae of *H. sericeus* were collected. This species has been known to be distributed in the northern area of the Pacific Ocean. At St. 52 (6º N, 138º E), it was heavily raining around the ship while trailed.

In the cruise, KT-07-19 on the northern edge of Kuroshio Current, *H. sericeus* was mainly collected in the northern-eastern area of 135º-140ºE, 34º-35ºN whereas *H. germanus and H. micans* were mainly collected in the relatively southern-western area of 131º-133ºE., 31º-33ºN. Only *H. sericeus* can be transferred by the Kuroshio Current onto the relatively northern-eastern area and to do reproduce at least in the summer season. In the cruise of KT-08-23, Most of "domestic" specimen collected in the area northern to Kuroshio current and near to Kyushu and Shikoku islands in September were *H. germanus* (Harada *et al.*, unpublished).

All samplings of *Halobates* have been performed at different geographical positions in any cruise in the Pacific Ocean so far. However, there has been no information on the dynamics in species and individual compositions in relatively eastern area of 145-160ºE, 0-10ºN of tropical Pacific Ocean. This study aims, first, to perform samplings in this area of the Western Pacific Ocean and examine dynamics of the species composition and reproductive and growth activity and compare these data to the data in the past which were got in more western area of 130-137ºE, 0-10ºN in the cruise, MR-06-05- Leg 3.

During the cruise, MR-08-02, on the longitudinal line of 130ºE, larvae of both *H. micans* and *H. germanus* were very abundant at 5-12º N, whereas adults of *H. sericeus* alone were dominant at 17º N. In the lower latitude area of 5-8 º N, all the three described species, *H. micans*, *H. germanus* and *H. sericeus* and un-described species, *Halobates moomario* (Harada *et al.*, unbublished) were collected. At a fixed point located at 12ºN, 135ºE, *H. micans* was dominant through the sampling period of 20 days, whereas *H. sericeus* was collected mainly in the latter half of the period. Higher number of *Halobates* (593) was collected in the first half of the sampling period (8^{th} – 17^{th} June, 2008) when the weather was very fine than that (427) in the second half (18^{th} – 27^{th} June, 2008) when the typhoon No 6 was born and developed near the fixed sampling point.

In this cruise of MR-09-04, on the longitudinal line of 155-156ºE *H. germanus* was very dominant, whereas three adults of *H. micans*, *H. germanus* and *H. sericeus* were dominant at 5º N on the longitudinal line of 147 ºE during this cruise held in Nov 4-Dec 12, 2009. Among several latitudes of 0-10 º N, peak of number of individuals collected was located at 8 º N, 5 º N and 0-2 º N for *H.m.*, *H.g.* and *H.s.*, respectively, on the longitudinal line of 155-156 º E. From latitudinal point of view, *H. micans* and *H.germanus*. were abundant in 5-8 º N, whereas *H. sericeus* and *H. moomario* were in 0-5 º N. Except for St. 6 at 3 º N, 147 º E, more than half of specimen collected were larvae at the remaining St. 1-5 and St.7,8.. Un-described new species, *Halobates moomario* was mostly on the longitudinal line of 147ºE. On the longitudinal line of 147 º E, more newly hatched larvae were collected than those on the line of 155-156E.

Fresh water species in Gerridae seem to have temperature tolerance from -3℃ to 42℃ (Harada, 2003), because water temperature in fresh water in ponds and river highly changes daily and seasonally. However, water temperatures in the ocean are relatively stable and only range from 24℃ to 30 ℃ in the center of Kuroshio current in southern front of western Japan (Harada, 2005). Adults of *Halobates germanus* showed semi-heat-paralysis (SHP: static posture with no or low frequency to skate on water surface), when they were exposed to temp. higher than 32℃ (Harada unpublished, data in the TANSEIMARU cruise: KT-05-27).

In contrast to the temperate ocean, water temperature in the tropical ocean area, is more stable around 30℃. Therefore, the tropical species of *H. micans* is hypothesized to have lower tolerances to temperature changes than the tropical-temperate species, *H. cericeus*. This hypothesis was true in the laboratory experiment during the cruise of KH-06-02-Leg 5 (Harada *et al.*, submitted). When the water temperature increased stepwise 1℃ every 1 hour, heat-paralysis (ventral surface of thorax attaché to water surface and unable to skate) occurred at 29℃ to >35 ℃ (increase by 1 to >7 ℃). Three of four specimens in *Halobates sericeus* were not paralyzed even at 35 ℃ and highly resistant to temperature change, while only one of nine in *H. micans.* and only four of twelve in *H. germanus* were not paralyzed at 35 ℃. On average, *H. sericeus, H germanus and H. micans* were paralyzed at >35.6 ℃ (SD: 0.89), >32.9 ℃(SD: 2.17) and >31.6 ℃ (SD: 2.60) on average, respectively (Harada *et al.*, submitted).

As an index of cold hardiness, super cooling points (SCPs) have been used in many insects (Bale, 1987, 1993; Worland, 2005). The absence of ice-nucleating agents and/or the lack of an accumulation of cryo-protective elements can often promote higher super cooling points (Milonas & Savopoulou-Soultani, 1999). SCPs, however, might be estimated as only the lower limits of supercooling capacity and only a theoretical lower threshold for the survival of insects as freeze-non-tolerant organisms. Many insects show considerable non-freezing mortality at temperatures well above the SCPs, a “chill-injury” species (Carrillo *et al.*, 2005; Liu *et al.*, 2007). Liu *et al* (2009) recently showed that SCPs change in accordance with the process of winter diapauses, decreasing in Dec-Feb and increasing rapidly in Feb-Apr (diapauses completing season) due to making glycogen from trehalose as a “blood suger” leading to lower osmotic pressure in haemolymph due to low “trehalose” level. This relation supports the possibility of SCPs available as an indirect indicator of cold hardiness of insects.

The 0-10ºN latitude-area in the Pacific Ocean has very complicated dynamic systems of ocean and atmosphere. Because of such complicated system, water/air temperatures and water conductivity (salinity) can be in dynamic change temporally and spatially. Sea skaters inhabiting this area of the Pacific Ocean show relatively high tolerance to temperature changes (heat tolerance)(Harada *et al.,* 2007: the cruise report of MR-06-05-Leg 3). However, there have been no data on the index on cold hardiness like as SCP on sea skaters yet. Recently, a cross-tolerance to high and low severe temperature has been reported by fresh water species of semi-aquatic bug, *Aquarius paludum* (Harada & Ishibashi, submitted). This study aims, second, to examine whether sea skaters living in very dynamic tropical sea area making “hot-water-pool” in tropical Pacific Ocean show high cross tolerance to high temperature and also lower super cooling points and also to examine some relationship between climate change at the fixed location and hardiness to high temperature and SCP as a index of cold hardiness of sea skaters.

(3) Samplings

Samplings were performed in 9st May– 20th June, 2010 with a Neuston NET (6 m long and with diameter of 1.3 m.)(Photo 5.21-1). The Neuston NET was trailed for 45min.(15mm x 3 times) on the sea surface at the fixed station of 5ºN, 139º30’E in the western Pacific Ocean on the right side of R/V MIRAI (8687t) which is owned by JAMSTEC (Japan Agency for Marine-earth Science and TECHnology). The trailing was performed for 15min mostly at night with the ship speed of 2.0 knot to the sea water (Table 5.21-1). It was repeated twice in each station. Surface area which was swept by Neuston NET was evaluated as a expression of [flow-meter value of ORI net trial at MR-06-05-Leg 3 x diameter of the ORI NET x (130 cm of width of the Neuston NET / 150cm of diameter of ORI NET) x 2.0knot /2.5 knot] based on the data obtained in the quite same samplings with ORI NET in MR-06-05-Leg 3. The area which was swept by the Neuston-NET during the trailing for 45 min can be estimated as the value of 2905.12 m^2 on average).

(4) Method of experiment

Laboratory experiment

Sea skaters trapped in the pants (grey plastic bottle)**(**Photo 5.21-2) located and fixed at the end of Neuston NET were paralyzed with the physical shock due to the trailing of the NET. Such paralyzed sea skaters were transferred on the surface of paper towel and to respire. Then, the paralysis of some ones was discontinued within 20min. When sea skaters were trapped in the jelly of jelly fishes, the jelly was removed from the body of sea skaters very carefully and quickly by hand for the recovering out of the paralysis.

All the adults and 5th instars which recovered out of the paralysis were moved on the sea water in the aquaria set in the laboratory for the Heat-Paralysis Experiments. Many white cube aquaria with 30cm X 30cm X 40cm) were used in the laboratory of the ship for the rearing of the adults and larvae which were recovered out of the paralysis due to the trailing. Each aquarium contained ten to twenty adults or larvae of *Halobates*. Both the room temperature and sea water temperature in the aquaria were kept at 29±2℃. More than 12 hours after the collection, sea skaters were kept in the aquaria before the heat-paralysis experiment. Air was supplied to the sea water for the rearing and heat paralysis experiment in aquaria to prevent the increase of water surface viscosity due to bacterial activity. Without air supplying system, bodies of sea skaters would be caught by the water film several hours later and could not be kept long in the aquaria. All the individuals of *Halobates* kept in the aquaria were fed on mainly adult flies, *Lucillia illustris* before the heat-paralysis experiments. The transparent aquarium as the experimental arena has sea water with the same temperature (mostly 28 or 29℃) as that of the aquarium to keep sea skaters. 1 to 14 individuals at adult or larval stage were moved to the transparent aquarium. Temperature was stepwise increased by 1℃ every 1 hour till the high temperature paralysis occurring in all the experimental specimens.

Temperature was very precisely controlled by handy on-off-switching to keep in ±0.3 ℃ of the current water temperature. Handy-stirring with 10cm air tube with 5mm diameter and ball stone with 3cm diameter and supplying sea water of 26℃ with a syringe were effective to keep the precise controlling of the current temperature. Sea skaters on the water surface of the aquarium were recorded with Digital Handy Video Camera (GZ-MG840-S: VICTOR) from above position for the last fifteen of each 1hour under the current temperature. Temperature at which Semi High Temperature Paralysis (SHTP: no or little movement on the water surface:

and High Temperature Paralysis (HTP: ventral surface of the body was caught by sea water film and no ability to skate any more) were recorded.

Determination of super cooling points (SCPs)

The determination of super cooling points was performed for the specimen (mainly adults) paralyzed by high temperature of the four species of oceanic *Halobates* (*H. micans, H. germanus, H. sericeus, H. megamoohmario* as a new proposed species) at the end of heat paralysis experiment during this cruise. Surface of each adult was dried with filter paper, and thermocouples with consist of nickel and bronze were attached to the abdominal surface of the thorax and connected to automatic temperature recorders (Digital Thermometer, Yokogawa Co, LTD, Model 10, Made in Japan). The thermocouple was completely fixed to be attached to the ventral surface of abdomen by a kind of Sellotape. The specimen attached to thermocouples was placed into a compressed-styroform box (5×5×3 cm^3) whch was again set inside another insulating larger compressed Styrofoam to ensure that the cooling rate was about 1×℃/min for recording the SCP in the freezer in which temperature was -35℃. The lowest temperature which reached before an exothermic event occurred due to release of latent heat was regarded as the SCP (Zhao & Kang, 2000). All tested specimen were killed by the body-freezing when SCP was determined.

(5) Results

Distribution (Table 5.21-1)

During the samplings for the long period more than one month at the fixed station of 5ºN, 139º30', five species of *Halobates micans, H.germanus, H. sericeus, H. megamoomario, H. moomario* were collected, although *H. micans* inhabit this area dominantly. The relationship of number of sea skaters collected and several physical factors (precipitation, air temperature, wave height etc) will be analyzed very soon.

Laboratory experiment (Table 5.21-2)

Temperature for temp for heat paralysis (THP), gap temp. for heat paralysis (GTHP) and super cooling point (SCP) were ranged 30 ºC to 40 ºC, 1ºC to 10 ºC, and -20.7 ºC to -9.2 ºC, respectively. The correlation analysis between THP and SCP will be analyzed very soon. In addition to that, the relationship between heat hardiness and SCP, and several physical parameters in each day when sampling should be also analyzed.

Additional Analysis

The data on field samplings in this study and environmental data on the oceanography during the cruise should be compared to the sampling data and related oceanography data in the area of 0-8 º N, 130-138 º E, in the Pacific Ocean at the cruise, MR-06-05-Leg 3 in the western tropical Pacific Ocean, as well as those in the area of 8 º N to 6 º S in the Indian Ocean at the cruise, KH-07-04-Leg1 (Harada *et al.*, 2008), those in the area of 30-35 º N along the Kuroshio Current at the cruise, KT-07-19, KT-08-23, KT-09-20.

Cross tolerance between heat and cold hardiness was shown by *Halobates* inhabiting western tropical Pacific Ocean with 0-8N, 147-156E during the MR-09-04. Similar analysis and comparative analysis will be done very soon with the current data in this study on SCP and heat paralysis experiment on *Halobates*. SCP measurement and heat paralysis experiment were done in the same manner during the cruise KT-09-20 in September, 2009. The relationship of the extent of the heat tolerance and SCP value to the ocean dynamics including several currents in the Pacific and Indian Ocean and also to the biological productivity by phyto-planktons and zoo-planktons should be analyzed in the near future.

The video camera data will be analyzed very soon after the cruise to examine the frequency and speed of skating and their responses to the temperature differences.

(6) Acknowledgements

We would like to thank Dr. Hiroyuki YAMADA (Head Scientist of the cruise: MR-10-03) for the permission to do this study during the cruise on the R/V MIRAI, for his warm suggestion on ocean dynamics, and encouragement and help throughout this cruise. The samplings and the experimental study were also possible due to supports from all of the crew (Captain: Mr. Yasushi ISHIOKA) and all the scientists and the engineers from GODI and MWJ in this cruise. We would like to give special thanks to them.

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Table 5.21-1-A. Number of *Halobates* collected at 27 locations in the western region of the pacific ocean in Nov 12, 2009 to Dec 04, 2009. (N:Total number of individuals collected; *H.m.: Halobates micans; H.g.: Halobates germanus; H.s.: Halobates sericeus*; *H.moo*.:undescribed *Halobates moomario (new species)*; Stat: Station number; WT: Water temperature (℃); AT: Air temp.; L: N of larvae; A: N of adults, E: N of exuviae; Date: sampling date; Sampling was performed for 45min. EG: eggs on some substrates like as polystyrene form thousands of eggs laid on the substrate. Surface area which was swept by Neuston NET was expressed as value of flow-meter x diameter of the ORI NET x (130 cm of width of Neuston NET / 150cm of diameter of ORI NET) based on the data obtained in the quite same samplings with ORI NET in MR-06-05-Leg 3 (estimated value: 3631.4 m^2 on average for Nesston NET trailing for 45 min); WS: wind velocity (m/s); W: weather; TD: Time of day; WV: Wing velocity

Latitude	Longitude	N	L	A	*H.m.*	*H.g.*	*H.s.*	*H.megamoo.*	*H.moo*	EG	E	Stat	WT	AT	WV	W	TD	Date
07˚50’N	140˚12’	73	54	19	71	2	0	0	0	0	0	St.1	29.3	29.5	9.7	Fine	18:30~	May 9
05˚01’N	139˚31’	36	29	7	28	6	1	1	0	0	0	St.2	29.8	29.5	8.1	Fine	18:57~	May 16
05˚00’N	139˚31’	173	147	26	147	24	0	0	2	0	0	St.3	29.9	30.2	6.3	Fine	18:58~	May 17
05˚01’N	139˚31’	127	113	14	122	5	0	0	0	0	0	St.4	30.1	29.8	6.7	Fine	18:42~	May 18
05˚01’N	139˚30’	250	239	11	227	23	0	0	0	0	0	St.5	30.2	28.7	2.8	Fine	18:42~	May 20
05˚00’N	139˚31’	119	104	15	116	2	0	0	1	0	0	St.6	30.0	30.1	8.0	Fine	18:41~	May 21
04˚59’N	139˚30’	24	19	5	24	0	0	0	0	0	0	St.7	30.0	29.5	2.7	Fine	18:46~	May 22
05˚01’N	139˚30’	588	572	16	584	4	0	0	0	0	0	St.8	30.0	28.7	4.3	Fine	18:44~	May 23
05˚00’N	139˚30’	232	222	10	232	0	0	0	0	0	0	St.9	30.1	28.8	7.7	C/R	18:48~	May 25
05˚00’N	139˚30’	195	187	8	193	0	0	0	2	0	0	St.10	29.9	26.5	2.3	Rain	18:50~	May 26
05˚00’N	139˚31’	246	219	27	244	0	0	0	2	0	0	St.11	29.9	27.3	1.9	Rain	18:41~	May 27
05˚00’N	139˚31’	98	82	16	98	0	0	0	0	0	0	St.12	29.2	29.9	6.6	Fine	18:39~	May 28
05˚00’N	139˚31’	97	88	9	97	0	0	0	0	0	0	St.13	30.0	30.0	2.0	Fine	18:39~	May 30
04˚59’N	139˚31’	97	73	24	97	0	0	0	0	0	0	St.14	30.1	29.4	3.8	Fine	18:39~	May 31
04˚59’N	139˚31’	92	84	8	92	0	0	0	0	0	0	St.15	31.0	29.9	2.9	C/R	18:40~	June 1
04˚59’N	139˚31’	20	18	2	20	0	0	0	0	0	0	St.16	29.7	28.6	5.9	C(R)	18:43~	June 3
05˚00’N	139˚31’	508	491	17	504	0	0	0	4	0	0	St.17	30.2	30.2	4.2	Fine	18:41~	June 4
05˚00’N	139˚31’	184	180	4	181	0	0	0	3	0	0	St.18	30.2	30.3	4.2	Fine	18:40~	June 5
05˚00’N	139˚30’	77	72	5	76	0	0	0	1	0	0	St.19	30.0	29.8	3.2	Fine	18:44~	June 7
05˚00’N	139˚30’	184	151	33	182	0	0	0	2	0	0	St.20	30.5	29.4	3.2	Fine	18:44~	June 8
05˚00’N	139˚30’	68	55	13	68	0	0	0	0	0	0	St.21	30.0	27.7	4.8	R/C	19:08~	June 9
05˚00’N	139˚30’	60	44	16	57	0	0	0	3	0	0	St.22	30.0	30.3	6.1	Fine	18:39~	June 11
05˚00’N	139˚30’	148	130	18	145	0	0	0	3	0	0	St.23	29.8	28.5	5.4	R/C	18:41~	June 12
05˚00’N	139˚30’	93	75	18	92	0	0	0	1	0	0	St.24	30.0	30.4	6.8	Fine	18:39~	June 13
04˚58’N	139˚30’	117	105	12	117	0	0	0	0	0	0	St.25	29.8	27.0	2.2	Cloudy	18:41~	June 15
05˚00’N	139˚31’	90	83	7	89	0	0	0	1	0	0	St.26	30.0	29.7	6.1	Fine	18:38~	June 16
05˚00’N	139˚31’	29	24	5	29	0	0	0	0	0	0	St.27	30.0	29.7	5.9	Fine	18:38~	June 17

Table 5.21-1-B. Number of *Halobates* collected at 2 locations in the western region of the pacific ocean in Nov 12, 2009 to Dec 04, 2009. (N:Total number of individuals collected; *H.m.: Halobates micans; H.g.: Halobates germanus; H.s.: Halobates sericeus*; *H.moo*.: *Halobates moomario (new species under description)*; *H.megamoo*.: un-described *Halobates megamoomario (new species under description)*Stat: Station number; WT: Water temperature (℃); AT: Air temp.; L: N of larvae; A: N of adults, E: N of exuviae; Date: sampling date; Sampling was performed for 45min. EG: eggs on some substrates like as polystyrene form thousands of eggs laid on the substrate. Surface area which was swept by Neuston NET was expressed as value of flow-meter x diameter of the ORI NET x (130 cm of width of Neuston NET / 150cm of diameter of ORI NET) based on the data obtained in the quite same samplings with ORI NET in MR-06-05-Leg 3 (estimated value: 3631.4 m^2 on average for Nesston NET trailing for 45 min); WS: wind velocity (m/s); W: weather; TD: Time of day; WV: Wing velocity.

Latitude	Longitude	N	L	A	*H.m.*	*H.g.*	*H.s.*	*H.megamoo.*	*H.moo*	EG	E	Stat	WT	AT	WV	W	TD	Date
05˚00'N	**139˚31'**	**27**	**23**	**4**	**25**	**0**	**0**	**0**	**2**	**0**	**0**	**St.28**	**29.8**	**29.3**	**5.4**	**F/HR**	**18:39~**	**June 19**
04˚59'N	**139˚31'**	**103**	**89**	**14**	**102**	**0**	**0**	**0**	**1**	**0**	**0**	**St.29**	**29.7**	**28.6**	**5.2**	**Rainy**	**18:38~**	**June 20**
Total556																		
(all 29 locations)		**4155**	**3772**	**383**	**4059**	**66**	**1**	**1**	**28**	**0**								

Table 5.21-2 (Sheet 1). Results of "heat-paralysis" experiments and SCP (Super Cooling Point) measurement performed on larvae and adults of *Halobates micans* (H.m.), *H.germanus*(H.g.), *H. sericeus*(H.s.) and un-described new species *H. moomario* (proposed name: H. moo.) TA: temp. at which specimen adapted, THP: temp. at which heat-paralysis occurred ; GTHP: gap temp. for heat paralysis (from base temp.); "Date and Time of day" when experiments were performed. (MR-09-04: Nov. 4-Dec 12, 2009), ITSCP: Increased temperature at SCP TD: Time of day; Increase in temp. at SCP shown in the parenthesis after SCP

St.No.	Latitude(N)	Longitude(E)	Exp.No.	TA	THP	GTHP	SCP	ITSCP	Species	Stage (sex)	Date	TD
St. 1	07˚50'N	140˚12'	1	30	31	1	-12.4	4.8	H.m.	Adult (male)	May 10	06:45~
St. 1	07˚50'N	140˚12'	1	30	31	1	-	-	H.m.	5th instar	May 10	06:45~
St. 1	07˚50'N	140˚12'	1	30	32	2	-15.8	1.6	H.m.	5th instar	May 10	06:45~
St. 1	07˚50'N	140˚12'	1	30	32	2	-16.3	2.1	H.m.	Adult (female)	May 10	06:45~
St. 1	07˚50'N	140˚12'	1	30	32	2	-15.1	3.0	H.m.	Adult (female)	May 10	06:45~
St. 1	07˚50'N	140˚12'	1	30	33	3	-17.6	4.7	H.m.	Adult (male)	May 10	06:45~
St. 1	07˚50'N	140˚12'	1	30	33	3	-15.5	4.3	H.m.	Adult (female)	May 10	06:45~
St. 1	07˚50'N	140˚12'	1	30	33	3	-15.6	1.0	H.m.	Adult (male)	May 10	06:45~
St. 1	07˚50'N	140˚12'	1	30	34	4	-18.2	1.3	H.m.	Adult (female)	May 10	06:45~
St. 1	07˚50'N	140˚12'	1	30	34	4	-17.2	1.8	H.m.	Adult (male)	May 10	06:45~
St. 1	07˚50'N	140˚12'	2	30	33	3	-15.8	3.1	H.m.	5th instar	May 10	06:45~
St. 1	07˚50'N	140˚12'	2	30	34	4	-13.5	2.9	H.m.	5th instar	May 10	06:45~
St. 1	07˚50'N	140˚12'	2	30	34	4	-	-	H.m.	Adult (female)	May 10	06:45~
St. 1	07˚50'N	140˚12'	2	30	34	4	-09.6	6.0	H.m.	Adult (female)	May 10	06:45~
St. 2	05˚01'N	139˚31'	3	30	31	1	-16.5	5.6	H.megamoo.	Adult(male)	May 17	06:45~
St. 2	05˚01'N	139˚31'	3	30	33	3	-	-	H.m.	Adult(female)	May 17	06:45~
St. 2	05˚01'N	139˚31'	3	30	35	5	-	-	H.g.	Adult(female)	May 17	06:45~
St. 2	05˚01'N	139˚31'	3	-	-	-	-16.0	3.1	H.g.	Adult(female)	May 17	06:45~
St. 3	05˚00'N	139˚31'	4	30	31	1	-13.0	1.2	H.m.	Adult(male)	May 18	06:45~
St. 3	05˚00'N	139˚31'	4	30	32	2	-15.3	1.6	H.m.	Adult(female)	May 18	06:45~
St. 3	05˚00'N	139˚31'	4	30	33	3	-17.9	4.4	H.m.	Adult(male)	May 18	06:45~
St. 3	05˚00'N	139˚31'	4	30	34	4	-	-	H.m.	Adult(male)	May 18	06:45~
St. 3	05˚00'N	139˚31'	4	30	37	7	-17.4	4.1	H.m.	Adult(male)	May 18	06:45~
St. 3	05˚00'N	139˚31'	4	30	38	8	-16.5	2.4	H.m.	Adult(female)	May 18	06:45~
St. 3	05˚00'N	139˚31'	4	30	38	8	-17.0	5.9	H.m.	Adult(male)	May 18	06:45~
St. 3	05˚00'N	139˚31'	4	30	39	9	-17.6	8.2	H.m.	Adult(female)	May 18	06:45~

Table 5.21-2 (Sheet 2). Results of "heat-paralysis" experiments and SCP (Super Cooling Point) measurement performed on larvae and adults of *Halobates micans* (H.m.), *H.germanus*(H.g.), *H. sericeus*(H.s.) and un-described new species *H. moomario* (proposed name: H. moo.) TA: temp. at which specimen adapted, THP: temp. at which heat-paralysis occurred ; GTHP: gap temp. for heat paralysis (from base temp.); "Date and Time of day" when experiments were performed. (MR-09-04: Nov. 4-Dec 12, 2009), ITSCP: Increased temperature at SCP TD: Time of day; Increase in temp. at SCP shown in the parenthesis after SCP

St.No.	Latitude(N)	Longitude(E)	Exp.No.	TA	THP	GTHP	SCP	ITSCP	Species	Stage (sex)	Date	TD
St. 4	05˚01'N	139˚31'	5	30	-	-	-15.8	2.0	H.m.	Adult(male)	May 19	06:45~
St. 4	05˚01'N	139˚31'	5	30	-	-	-14.5	8.7	H.m.	Adult(female)	May 19	06:45~
St. 4	05˚01'N	139˚31'	5	30	36	6	-19.4	1.4	H.m.	Adult(male)	May 19	06:45~
St. 4	05˚01'N	139˚31'	5	30	36	6	-19.4	0.9	H.m.	Adult(female)	May 19	06:45~
St. 4	05˚01'N	139˚31'	5	30	37	7	-17.8	2.9	H.m.	Adult(male)	May 19	06:45~
St. 4	05˚01'N	139˚31'	5	30	38	8	-16.9	2.4	H.m.	Adult(male)	May 19	06:45~
St. 4	05˚01'N	139˚31'	5	30	38	8	-	-	H.m.	Adult(male)	May 19	06:45~
St. 4	05˚01'N	139˚31'	5	30	38	8	-16.1	5.3	H.m.	Adult(male)	May 19	06:45~
St. 4	05˚01'N	139˚31'	5	30	39	9	-15.7	7.2	H.m.	Adult(female)	May 19	06:45~
St. 4	05˚01'N	139˚31'	5	30	40	10	-18.5	9.8	H.m.	Adult(female)	May 19	06:45~
St. 5	05˚01'N	139˚30'	6	-	-	-	-15.2	7.2	H.m.	Adult(male)	May 21	06:45~
St. 3,4, 5	05˚01'N	139˚30'	6	30	36	6	-18.6	7.2	H.m.	Adult(female)	May 21	06:45~
St. 3,4, 5	05˚01'N	139˚30'	6	30	36	6	-16.7	7.0	H.m.	Adult(female)	May 21	06:45~
St. 3,4, 5	05˚01'N	139˚30'	6	30	37	7	-19.1	5.5	H.m.	Adult(male)	May 21	06:45~
St. 3,4, 5	05˚01'N	139˚30'	6	30	40	10	-12.6	2.4	H.m.	Adult(male)	May 21	06:45~
St. 3,4, 5	05˚01'N	139˚30'	6	30	40	10	-14.0	1.8	H.m.	Adult(male)	May 21	06:45~
St. 6	05˚00'N	139˚31'	7	-	-	-	-14.3	2.5	H.m.	Adult(male)	May 22	06:45~
St. 6	05˚00'N	139˚31'	7	-	-	-	-15.8	1.5	H.m.	Adult(male)	May 22	06:45~
St. 6	05˚00'N	139˚31'	7	-	-	-	-13.6	5.0	H.m.	Adult(female)	May 22	06:45~
St. 4,5,6	05˚00'N	139˚31'	7	30	36	6	-17.8	4.5	H.m.	5th instar	May 22	06:45~
St. 4,5,6	05˚00'N	139˚31'	7	30	37	7	-14.9	3.3	H.m.	Adult(male)	May 22	06:45~
St. 4,5,6	05˚00'N	139˚31'	7	30	37	7	-14.9	8.3	H.m.	Adult(female)	May 22	06:45~
St. 4,5,6	05˚00'N	139˚31'	7	30	37	7	-16.7	6.2	H.m.	5th instar	May 22	06:45~
St. 4,5,6	05˚00'N	139˚31'	7	30	38	8	-19.3	5.3	H.m.	Adult(female)	May 22	06:45~
St. 4,5,6	05˚00'N	139˚31'	7	30	38	8	-15.6	11.0	H.m.	Adult(female)	May 22	06:45~
St. 4,5,6	05˚00'N	139˚31'	7	30	39	9	-16.3	8.6	H.m.	Adult(female)	May 22	06:45~
St. 4,5,6	05˚00'N	139˚31'	7	30	39	9	-18.5	8.8	H.m.	Adult(female)	May 22	06:45~

Table 5.21-2 (Sheet 3). Results of "heat-paralysis" experiments and SCP (Super Cooling Point) measurement performed on larvae and adults of *Halobates micans* (H.m.), *H.germanus*(H.g.), *H. sericeus*(H.s.) and un-described new species *H. moomario* (proposed name: H. moo.) TA: temp. at which specimen adapted, THP: temp. at which heat-paralysis occurred ; GTHP: gap temp. for heat paralysis (from base temp.); "Date and Time of day" when experiments were performed. (MR-09-04: Nov. 4-Dec 12, 2009), ITSCP: Increased temperature at SCP TD: Time of day; Increase in temp. at SCP shown in the parenthesis after SCP

St.No.	Latitude(N)	Longitude(E)	Exp.No.	TA	THP	GTHP	SCP	ITSCP	Species	Stage (sex)	Date	TD
St. 6	05˚00'N	139˚31'	8	-	-	-	-	-	H.m.	Adult(female)	May 23	06:45~
St. 6	05˚00'N	139˚31'	8	30	33	3	-18.5	6.5	H.m.	5th instar	May 23	06:45~
St. 6	05˚00'N	139˚31'	8	30	35	5	-17.2	4.5	H.m.	Adult(male)	May 23	06:45~
St. 6	05˚00'N	139˚31'	8	30	36	6	-15.8	1.5	H.m.	Adult(female)	May 23	06:45~
St. 6	05˚00'N	139˚31'	8	30	36	6	-16.4	10.8	H.m.	Adult(female)	May 23	06:45~
St. 6	05˚00'N	139˚31'	8	30	36	6	-15.0	9.1	H.m.	Adult(female)	May 23	06:45~
St. 6	05˚00'N	139˚31'	8	30	36	6	-16.9	6.1	H.m.	5th instar	May 23	06:45~
St. 6	05˚00'N	139˚31'	8	30	37	6	-16.0	9.2	H.m.	Adult(female)	May 23	06:45~
St. 7,8	05˚01'N	139˚30'	9	30	31	1	-17.1	5.2	H.m.	Adult(female)	May 25	06:45~
St. 7,8	05˚01'N	139˚30'	9	30	31	1	-15.7	3.5	H.m.	Adult(male)	May 25	06:45~
St. 7,8	05˚01'N	139˚30'	9	30	32	2	-16.6	2.8	H.m.	Adult(male)	May 25	06:45~
St. 7,8	05˚01'N	139˚30'	9	30	32	2	-15.1	1.1	H.m.	Adult(female)	May 25	06:45~
St. 7,8	05˚01'N	139˚30'	9	30	32	2	-14.9	1.0	H.m.	Adult(female)	May 25	06:45~
St. 7,8	05˚01'N	139˚30'	9	30	32	2	-17.2	1.9	H.m.	Adult(male)	May 25	06:45~
St. 7,8	05˚01'N	139˚30'	9	30	37	7	-17.0	3.5	H.m.	Adult(male)	May 25	06:45~
St. 7,8	05˚01'N	139˚30'	9	30	38	1	-20.6	9.1	H.m.	Adult(female)	May 25	06:45~
St. 8	05˚01'N	139˚30'	10	29	30	1	-09.2	6.6	H.m.	Adult(female)	May 26	06:45~
St. 8	05˚01'N	139˚30'	10	29	30	1	-12.7	6.5	H.m.	Adult(female)	May 26	06:45~
St. 8	05˚01'N	139˚30'	10	29	31	2	-10.8	2.4	H.m.	Adult(female)	May 26	06:45~
St. 8	05˚01'N	139˚30'	10	29	31	2	-15.8	5.3	H.m.	Adult(female)	May 26	06:45~
St. 8	05˚01'N	139˚30'	10	29	31	2	-17.6	5.2	H.m.	Adult(male)	May 26	06:45~
St. 8	05˚01'N	139˚30'	10	29	31	2	-14.7	4.9	H.m.	Adult(female)	May 26	06:45~
St. 8	05˚01'N	139˚30'	10	29	31	2	-20.6	12.1	H.m.	Adult(male)	May 26	06:45~

Table 5.21-2 (Sheet 4). Results of “heat-paralysis” experiments and SCP (Super Cooling Point) measurement performed on larvae and adults of *Halobates micans* (H.m.), *H.germanus*(H.g.), *H. sericeus*(H.s.) and un-described new species *H. moomario* (proposed name: H. moo.) TA: temp. at which specimen adapted, THP: temp. at which heat-paralysis occurred ; GTHP: gap temp. for heat paralysis (from base temp.); “Date and Time of day” when experiments were performed. (MR-09-04: Nov. 4-Dec 12, 2009), ITSCP: Increased temperature at SCP TD: Time of day; Increase in temp. at SCP shown in the parenthesis after SCP

St.No.	Latitude(N)	Longitude(E)	Exp.No.	TA	THP	GTHP	SCP	ITSCP	Species	Stage (sex)	Date	TD
St. 9	05˚00’N	139˚30’	11	30	37	7	-18.5	2.4	H.m.	Adult(female)	May 27	06:45~
St. 9	05˚00’N	139˚30’	11	30	38	8	-11.5	4.0	H.m.	Adult(male)	May 27	06:45~
St. 9	05˚00’N	139˚30’	11	30	39	9	-15.1	5.9	H.m.	Adult(male)	May 27	06:45~
St. 9	05˚00’N	139˚30’	11	30	40	10	-19.1	3.5	H.m.	Adult(male)	May 27	06:45~
St. 9	05˚00’N	139˚30’	11	30	40	10	-16.6	4.2	H.m.	Adult(female)	May 27	06:45~
St. 9	05˚00’N	139˚30’	11	30	40	10	-	-	H.m.	Adult(female)	May 27	06:45~
St. 9	05˚00’N	139˚30’	11	30	40	10	-18.7	2.4	H.m.	Adult(male)	May 27	06:45~
St. 10	05˚00’N	139˚30’	12	30	31	1	-16.5	6.3	H.m.	Adult(female)	May 29	06:45~
St. 10	05˚00’N	139˚30’	12	30	38	8	-17.5	8.9	H.m.	Adult(female)	May 29	06:45~
St. 10	05˚00’N	139˚30’	12	30	39	9	-15.0	8.7	H.m.	Adult(female)	May 29	06:45~
St. 10	05˚00’N	139˚30’	12	30	39	9	-09.2	1.4	H.m.	Adult(female)	May 29	06:45~
St. 10	05˚00’N	139˚30’	12	30	40	10	-16.4	3.9	H.m.	Adult(female)	May 29	06:45~
St. 11	05˚00’N	139˚31’	13	30	37	7	-15.0	6.3	H.m.	Adult(female)	May 30	06:45~
St. 11	05˚00’N	139˚31’	13	30	39	9	-20.7	2.8	H.m.	Adult(male)	May 30	06:45~
St. 11	05˚00’N	139˚31’	13	30	39	9	-18.8	4.8	H.m.	Adult(female)	May 30	06:45~
St. 11	05˚00’N	139˚31’	13	30	39	9	-19.6	8.5	H.m.	Adult(male)	May 30	06:45~
St. 11	05˚00’N	139˚31’	13	30	40	10	-17.1	4.8	H.m.	Adult(male)	May 30	06:45~
St. 11	05˚00’N	139˚31’	13	30	40	10	-18.0	7.5	H.m.	Adult(male)	May 30	06:45~
St. 11	05˚00’N	139˚31’	13	30	40	10	-20.2	10.6	H.m.	Adult(female)	May 30	06:45~
St. 11	05˚00’N	139˚31’	13	30	40	10	-16.5	6.0	H.m.	Adult(female)	May 30	06:45~
St. 11	05˚00’N	139˚31’	13	30	40	10	-18.7	5.2	H.m.	Adult(female)	May 30	06:45~
St. 13	05˚00’N	139˚31’	14	30	39	9	-18.9	12.6	H.m.	Adult(female)	May 31	06:45~
St. 13	05˚00’N	139˚31’	14	30	39	9	-19.5	11.1	H.m.	Adult(female)	May 31	06:45~
St. 13	05˚00’N	139˚31’	14	30	39	9	-16.2	6.3	H.m.	Adult(female)	May 31	06:45~
St. 13	05˚00’N	139˚31’	14	30	39	9	-17.5	7.6	H.m.	5th instar	May 31	06:45~
St. 13	05˚00’N	139˚31’	14	30	40	10	-20.1	9.3	H.m.	Adult(male)	May 31	06:45~
St. 13	05˚00’N	139˚31’	14	30	40	10	-18.7	4.8	H.m.	5th instar	May 31	06:45~
St. 13	05˚00’N	139˚31’	14	30	40	10	-15.0	7.0	H.m.	5th instar	May 31	06:45~
St. 13	05˚00’N	139˚31’	14	30	40	10	-16.8	6.7	H.m.	Adult(female)	May 31	06:45~

Table 5.21-2 (Sheet 5). Results of "heat-paralysis" experiments and SCP (Super Cooling Point) measurement performed on larvae and adults of *Halobates micans* (H.m.), *H.germanus*(H.g.), *H. sericeus*(H.s.) and un-described new species *H. moomario* (proposed name: H. moo.) TA: temp. at which specimen adapted, THP: temp. at which heat-paralysis occurred ; GTHP: gap temp. for heat paralysis (from base temp.); "Date and Time of day" when experiments were performed. (MR-09-04: Nov. 4-Dec 12, 2009), ITSCP: Increased temperature at SCP TD: Time of day; Increase in temp. at SCP shown in the parenthesis after SCP

St.No.	Latitude(N)	Longitude(E)	Exp.No.	TA	THP	GTHP	SCP	ITSCP	Species	Stage (sex)	Date	TD
St. 14	04˚59'N	139˚31'	15	30	37	7	-18.8	11.8	H.m.	Adult(male)	Jun 2	06:45~
St. 14	04˚59'N	139˚31'	15	30	38	8	-14.5	0.7	H.m.	Adult(male)	Jun 2	06:45~
St. 14	04˚59'N	139˚31'	15	30	38	8	-17.9	6.0	H.m.	5th instar	Jun 2	06:45~
St. 14	04˚59'N	139˚31'	15	30	38	8	-18.1	8.0	H.m.	Adult(female)	Jun 2	06:45~
St. 14	04˚59'N	139˚31'	15	30	39	9	-19.1	0.8	H.m.	Adult(female)	Jun 2	06:45~
St. 14	04˚59'N	139˚31'	15	30	39	9	-13.2	7.9	H.m.	Adult(female)	Jun 2	06:45~
St. 14	04˚59'N	139˚31'	15	30	39	9	-16.2	8.2	H.m.	Adult(female)	Jun 2	06:45~
St. 14	04˚59'N	139˚31'	15	30	40	10	-18.8	6.3	H.m.	Adult(male)	Jun 2	06:45~
St. 13	05˚00'N	139˚31'	16	-	-	-	-16.8	1.7	H.m.	Adult (male)	Jun 3	06:45~
St. 14	04˚59'N	139˚31'	16	30	37	7	-12.3	5.0	H.m.	Adult(male)	Jun 3	06:45~
St. 14	04˚59'N	139˚31'	16	30	38	8	-19.0	7.0	H.m.	Adult(female)	Jun 3	06:45~
St. 14	04˚59'N	139˚31'	16	30	38	8	-12.7	0.9	H.m.	Adult(female)	Jun 3	06:45~
St. 14	04˚59'N	139˚31'	16	30	38	8	-	-	H.m.	Adult(female)	Jun 3	06:45~
St. 17	05˚00'N	139˚31'	17	30	31	1	-15.4	5.0	H.m.	Adult(female)	Jun 4	06:45~
St. 17	05˚00'N	139˚31'	17	30	31	1	-14.3	2.1	H.m.	Adult(male)	Jun 4	06:45~
St. 17	05˚00'N	139˚31'	17	30	36	6	-19.1	6.1	H.m.	5th instar	Jun 4	06:45~
St. 17	05˚00'N	139˚31'	17	30	37	7	-16.7	7.6	H.m.	5th instar	Jun 4	06:45~
St. 17	05˚00'N	139˚31'	17	30	38	8	-17.3	12.3	H.m.	Adult(male)	Jun 4	06:45~
St. 17	05˚00'N	139˚31'	17	30	39	9	-14.7	1.5	H.m.	Adult(male)	Jun 4	06:45~
St. 17	05˚00'N	139˚31'	17	30	39	9	-15.5	4.0	H.m.	Adult(female)	Jun 4	06:45~
St. 17	05˚00'N	139˚31'	17	30	40	10	-16.7	3.7	H.m.	Adult(female)	Jun 4	06:45~
St. 17	05˚00'N	139˚31'	18	30	38	8	-14.3	8.1	H.m.	Adult(female)	Jun 6	06:45~
St. 17	05˚00'N	139˚31'	18	30	39	9	-19.4	6.5	H.m.	Adult(male)	Jun 6	06:45~
St. 17	05˚00'N	139˚31'	18	30	39	9	-17.7	3.7	H.m.	Adult(male)	Jun 6	06:45~
St. 17	05˚00'N	139˚31'	18	30	39	9	-19.2	5.8	H.m.	Adult(female)	Jun 6	06:45~
St. 17	05˚00'N	139˚31'	18	30	40	10	-14.4	8.4	H.m.	Adult(female)	Jun 6	06:45~
St. 17	05˚00'N	139˚31'	18	30	40	10	-16.4	9.9	H.m.	Adult(female)	Jun 6	06:45~

Table 5.21-2 (Sheet 6). Results of "heat-paralysis" experiments and SCP (Super Cooling Point) measurement performed on larvae and adults of *Halobates micans* (H.m.), *H.germanus*(H.g.), *H. sericeus*(H.s.) and un-described new species *H. moomario* (proposed name: H. moo.) TA: temp. at which specimen adapted, THP: temp. at which heat-paralysis occurred ; GTHP: gap temp. for heat paralysis (from base temp.); "Date and Time of day" when experiments were performed. (MR-09-04: Nov. 4-Dec 12, 2009), ITSCP: Increased temperature at SCP TD: Time of day; Increase in temp. at SCP shown in the parenthesis after SCP

St.No.	Latitude(N)	Longitude(E)	Exp.No.	TA	THP	GTHP	SCP	ITSCP	Species	Stage (sex)	Date	TD
St. 19	05˚00'N	139˚30'	19	30	31	1	-16.6	5.4	H.m.	Adult(male)	Jun 7	06:45~
St. 19	05˚00'N	139˚30'	19	30	33	3	-16.2	5.5	H.m.	Adult(male)	Jun 7	06:45~
St. 19	05˚00'N	139˚30'	19	30	34	4	-	-	H.m.	Adult(female)	Jun 7	06:45~
St. 19	05˚00'N	139˚30'	19	30	38	8	-21.1	5.2	H.m.	Adult(male)	Jun 7	06:45~
St. 20	05˚00'N	139˚30'	20	30	36	6	-16.8	6.8	H.m.	5th instar	Jun 8	06:45~
St. 20	05˚00'N	139˚30'	20	30	36	6	-12.7	6.2	H.m.	Adult(male)	Jun 8	06:45~
St. 20	05˚00'N	139˚30'	20	30	37	7	-16.9	7.4	H.m.	5th instar	Jun 8	06:45~
St. 20	05˚00'N	139˚30'	20	30	38	8	-13.5	1.6	H.m.	Adult(male)	Jun 8	06:45~
St. 20	05˚00'N	139˚30'	20	30	38	8	-13.3	8.4	H.m.	Adult(female)	Jun 8	06:45~
St. 20	05˚00'N	139˚30'	20	30	39	9	-16.8	7.4	H.m.	Adult(female)	Jun 8	06:45~
St. 20	05˚00'N	139˚30'	21	30	37	7	-17.6	7.0	H.m.	Adult(male)	Jun 10	06:45~
St. 20	05˚00'N	139˚30'	21	30	38	8	-17.3	0.6	H.m.	Adult(male)	Jun 10	06:45~
St. 20	05˚00'N	139˚30'	21	30	39	9	-20.8	4.1	H.m.	Adult(male)	Jun 10	06:45~
St. 20	05˚00'N	139˚30'	21	30	39	9	-18.2	2.0	H.m.	Adult(male)	Jun 10	06:45~
St. 20	05˚00'N	139˚30'	21	30	40	10	-20.2	8.2	H.m.	Adult(female)	Jun 10	06:45~
St. 20	05˚00'N	139˚30'	21	30	40	10	-15.5	1.7	H.m.	Adult(male)	Jun 10	06:45~
St. 20	05˚00'N	139˚30'	21	30	40	10	-11.5	2.5	H.m.	Adult(male)	Jun 10	06:45~
St. 20	05˚00'N	139˚30'	21	30	40	10	-17.8	2.0	H.m.	Adult(male)	Jun 10	06:45~
St. 21	05˚00'N	139˚30'	22	-	-	-	-17.7	7.1	H.m.	Adult(male)	Jun 11	06:45~
St. 21	05˚00'N	139˚30'	22	-	-	-	-17.5	11.1	H.m.	Adult(female)	Jun 11	06:45~
St. 21	05˚00'N	139˚30'	22	-	-	-	-15.7	5.7	H.m.	Adult(female)	Jun 11	06:45~
St. 21	05˚00'N	139˚30'	22	30	36	6	-15.7	7.7	H.m.	Adult(male)	Jun 11	06:45~
St. 21	05˚00'N	139˚30'	22	30	36	6	-14.5	5.3	H.m.	Adult(female)	Jun 11	06:45~
St. 21	05˚00'N	139˚30'	22	30	36	6	-14.5	6.1	H.m.	Adult(female)	Jun 11	06:45~
St. 21	05˚00'N	139˚30'	22	30	39	9	-18.3	1.1	H.m.	Adult(male)	Jun 11	06:45~
St. 21	05˚00'N	139˚30'	22	30	39	9	-18.9	9.2	H.m.	Adult(female)	Jun 11	06:45~

Table 5.21-2 (Sheet 7). Results of "heat-paralysis" experiments and SCP (Super Cooling Point) measurement performed on larvae and adults of *Halobates micans* (H.m.), *H.germanus*(H.g.), *H. sericeus*(H.s.) and un-described new species *H. moomario* (proposed name: H. moo.) TA: temp. at which specimen adapted, THP: temp. at which heat-paralysis occurred ; GTHP: gap temp. for heat paralysis (from base temp.); "Date and Time of day" when experiments were performed. (MR-09-04: Nov. 4-Dec 12, 2009), ITSCP: Increased temperature at SCP TD: Time of day; Increase in temp. at SCP shown in the parenthesis after SCP

St.No.	Latitude(N)	Longitude(E)	Exp.No.	TA	THP	GTHP	SCP	ITSCP	Species	Stage (sex)	Date	TD
St. 22	05˚00'N	139˚30'	23	30	37	7	-19.1	0.5	H.m.	Adult(female)	Jun 12	06:45~
St. 22	05˚00'N	139˚30'	23	30	39	9	-18.0	0.6	H.m.	Adult(female)	Jun 12	06:45~
St. 22	05˚00'N	139˚30'	23	30	39	9	-19.1	7.5	H.m.	Adult(male)	Jun 12	06:45~
St. 22	05˚00'N	139˚30'	23	30	40	10	-18.4	8.5	H.m.	5th instar	Jun 12	06:45~
St. 22	05˚00'N	139˚30'	23	30	40	10	-	-	H.m.	Adult(female)	Jun 12	06:45~
St. 22	05˚00'N	139˚30'	23	30	40	10	-15.0	6.3	H.m.	5th instar	Jun 12	06:45~
St. 22	05˚00'N	139˚30'	23	30	40	10	-14.8	2.8	H.m.	Adult(female)	Jun 12	06:45~
St. 22	05˚00'N	139˚30'	23	30	40	10	-12.1	6.2	H.m.	5th instar	Jun 12	06:45~
St. 22	05˚00'N	139˚30'	24	30	31	1	-18.2	10.1	H.m.	Adult(male)	Jun 14	06:45~
St. 22	05˚00'N	139˚30'	24	30	36	6	-16.7	1.8	H.m.	Adult(female)	Jun 14	06:45~
St. 22	05˚00'N	139˚30'	24	30	36	6	-20.7	3.5	H.m.	Adult(female)	Jun 14	06:45~
St. 22	05˚00'N	139˚30'	24	30	37	7	-20.9	4.5	H.m.	Adult(female)	Jun 14	06:45~
St. 22	05˚00'N	139˚30'	24	30	39	9	-17.6	0.6	H.m.	Adult(male)	Jun 14	06:45~
St. 22	05˚00'N	139˚30'	24	30	39	9	-16.9	8.2	H.m.	Adult(male)	Jun 14	06:45~
St. 22	05˚00'N	139˚30'	24	30	39	9	-16.1	7.1	H.m.	Adult(male)	Jun 14	06:45~
St. 22	05˚00'N	139˚30'	24	30	40	10	-20.1	8.0	H.m.	Adult(female)	Jun 14	06:45~
St. 23	05˚00'N	139˚30'	25	30	37	7	-17.9	9.6	H.m.	Adult(female)	Jun 15	06:45~
St. 23	05˚00'N	139˚30'	25	30	38	8	-	-	H.m.	Adult(female)	Jun 15	06:45~
St. 23	05˚00'N	139˚30'	25	30	38	8	-17.1	3.6	H.m.	Adult(female)	Jun 15	06:45~
St. 23	05˚00'N	139˚30'	25	30	39	9	-15.0	4.9	H.m.	Adult(male)	Jun 15	06:45~
St. 25	04˚58'N	139˚30'	26	30	34	4	-16.7	5.8	H.m.	Adult(male)	Jun 16	06:45~
St. 25	04˚58'N	139˚30'	26	30	37	7	-17.0	12.3	H.m.	Adult(male)	Jun 16	06:45~
St. 25	04˚58'N	139˚30'	26	30	38	8	-16.8	1.7	H.m.	Adult(male)	Jun 16	06:45~
St. 25	04˚58'N	139˚30'	26	30	38	8	-19.0	1.7	H.m.	Adult(female)	Jun 16	06:45~
St. 25	04˚58'N	139˚30'	26	30	38	8	-15.4	0.4	H.m.	Adult(female)	Jun 16	06:45~
St. 25	04˚58'N	139˚30'	26	30	39	9	-14.4	4.1	H.m.	Adult(female)	Jun 16	06:45~
St. 25	04˚58'N	139˚30'	26	30	39	9	-16.5	8.3	H.m.	Adult(male)	Jun 16	06:45~
St. 25	04˚58'N	139˚30'	26	30	39	9	-15.6	1.5	H.m.	Adult(male)	Jun 16	06:45~

Table 5.21-2 (Sheet 8). Results of "heat-paralysis" experiments and SCP (Super Cooling Point) measurement performed on larvae and adults of *Halobates micans* (H.m.), *H.germanus*(H.g.), *H. sericeus*(H.s.) and un-described new species *H. moomario* (proposed name: H. moo.) TA: temp. at which specimen adapted, THP: temp. at which heat-paralysis occurred ; GTHP: gap temp. for heat paralysis (from base temp.); "Date and Time of day" when experiments were performed. (MR-09-04: Nov. 4-Dec 12, 2009), ITSCP: Increased temperature at SCP TD: Time of day; Increase in temp. at SCP shown in the parenthesis after SCP

St.No.	Latitude(N)	Longitude(E)	Exp.No.	TA	THP	GTHP	SCP	ITSCP	Species	Stage (sex)	Date	TD
St. 26	05˚00'N	139˚31'	27	30	37	7	-17.4	5.5	H.m.	Adult(female)	Jun 18	06:45~
St. 26	05˚00'N	139˚31'	27	30	37	7	-16.0	5.2	H.m.	Adult(female)	Jun 18	06:45~
St. 26	05˚00'N	139˚31'	27	30	37	7	-16.8	11.7	H.m.	Adult(female)	Jun 18	06:45~
St. 26	05˚00'N	139˚31'	27	30	38	8	-15.8	8.4	H.m.	5th instar	Jun 18	06:45~
St. 26	05˚00'N	139˚31'	27	30	38	8	-18.3	8.9	H.m.	Adult(female)	Jun 18	06:45~
St. 26	05˚00'N	139˚31'	27	30	39	9	-16.4	7.0	H.m.	Adult(female)	Jun 18	06:45~
St. 28	05˚00'N	139˚31'	28	30	32	2	-17.2	2.4	H.m.	5th instar	Jun 19	06:45~
St. 28	05˚00'N	139˚31'	28	30	38	8	-15.3	5.9	H.m.	Adult(male)	Jun 19	06:45~
St. 28	05˚00'N	139˚31'	28	30	39	9	-17.6	5.3	H.m.	Adult(female)	Jun 19	06:45~
St. 28	05˚00'N	139˚31'	28	30	39	8	-17.9	3.1	H.m.	Adult(male)	Jun 19	06:45~
St. 29	04˚59'N	139˚31'	29	30	33	3	-	-	H.m.	Adult(female)	Jun 20	06:45~
St. 29	04˚59'N	139˚31'	29	30	38	8	-15.3	1.2	H.m.	Adult(female)	Jun 20	06:45~
St. 29	04˚59'N	139˚31'	29	30	38	8	-17.2	6.1	H.m.	Adult(male)	Jun 20	06:45~
St. 29	04˚59'N	139˚31'	29	30	38	8	-14.3	3.1	H.m.	Adult(male)	Jun 20	06:45~
St. 29	04˚59'N	139˚31'	29	30	39	9	-	-	H.m.	Adult(female)	Jun 20	06:45~
St. 29	04˚59'N	139˚31'	29	30	39	9	-19.7	5.5	H.m.	Adult(male)	Jun 20	06:45~
St. 29	04˚59'N	139˚31'	29	30	39	9	-17.7	6.6	H.m.	Adult(male)	Jun 20	06:45~
St. 29	04˚59'N	139˚31'	29	30	39	9	-16.1	3.7	H.m.	Adult(female)	Jun 20	06:45~
St. 29	04˚59'N	139˚31'	29	30	40	10	-15.6	7.8	H.m.	Adult(male)	Jun 20	06:45~
St. 29	04˚59'N	139˚31'	29	30	40	10	-18.6	6.8	H.m.	Adult(male)	Jun 20	06:45~

Photo 5.21-1: a trailing scene of Neuston-NET

Photo 5.21-2: Washing the "pants" of the Neuston net just after the trailing to collect all the *Halobates* individuals into the round-shaped transparent aquarium.

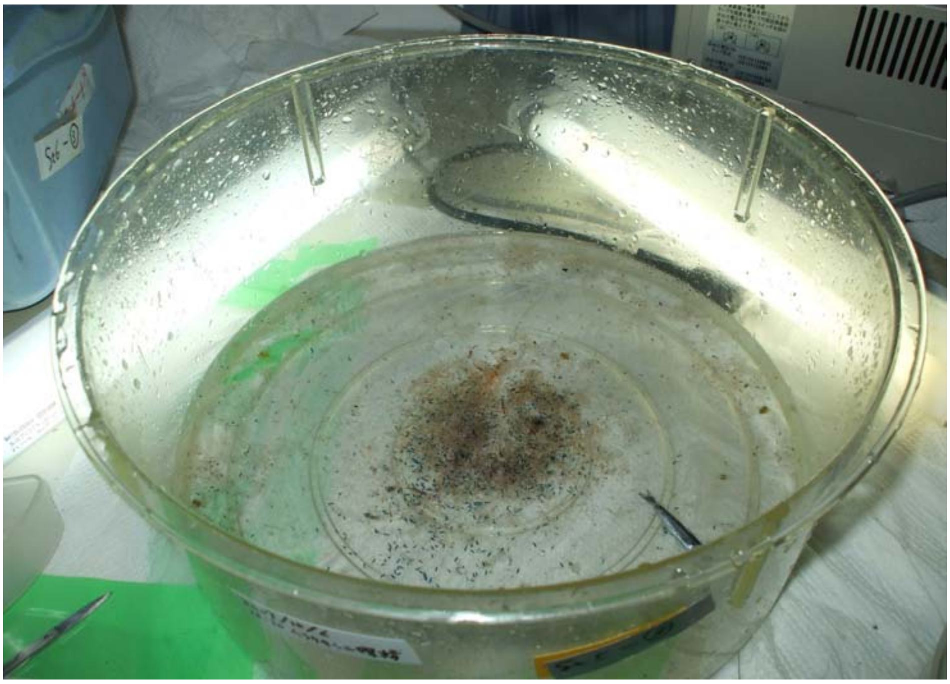


Photo 5.21-3: An example of the sample of Neuston-NET trailing.

Photo 5.21-4: Laboratory showing the heat paralysis experiment arena (on the left) and incubating aquaria filled with sea water into which air was supplied from pomp and air tubes for keeping freshmen of the sea water. Air temperature was kept within 29±2℃ with air-conditioners.

Photo 5.21-5: A female of *Halobates moomario* (a new species under description) under semi-paralysis in which she is in completely static posture without no movement at all due to increased temperature. Low of hairs like “oar” can be seen in the tibia and tarsus of the left hind leg.

Photo 5.21-6: A scene in which super cooling point (SCP) was measured with automatic temperature recorders With a thermo-sensor consisting of nickel-bronze coupling and freezer in which temperature was kept at -35℃. When heat paralysis occurred in a specimen, he (or she) is attached with the thermo-coupling at ventral surface of abdomen and transferred inside a box made of high-dense-type-polystyrene-form (another box can be seen on the freezer) and then put into the freezer to measure SCP.

5.22 Underway Geophysics

5.22.1 Sea Surface Gravity

(1) Personnel

Takeshi MATSUMOTO (University of the Ryukyus) : Principal Investigator (Not on-board)
Souichiro SUEYOSHI (Global Ocean Development Inc., GODI)
Harumi OTA (GODI)
Asuka DOI (GODI)
Ryo OHYAMA (MIRAI Crew)

(2) Introduction

The local gravity is an important parameter in geophysics and geodesy. We collected gravity data at the sea surface.

(3) Parameters

Relative Gravity [CU: Counter Unit]
[mGal] = (coef1: 0.9946) * [CU]

(4) Data Acquisition

We measured relative gravity using LaCoste and Romberg air-sea gravity meter S-116 (Micro-g LaCoste, LLC) during the MR10-03 cruise from 5th May 2010 to 28th June 2010.

To convert the relative gravity to absolute one, we measured gravity, using portable gravity meter (Scintrex gravity meter CG-3M), at Sekinehama and Moji as the reference point.

(5) Preliminary Results

Absolute gravity shown in Tabel 5.22.1-1

(6) Data Archives

Surface gravity data obtained during this cruise will be submitted to the Data Integration and Analysis Group (DIAG) in JAMSTEC, and will be archived there.

(7) Remarks

1) Following periods, data acquisition was suspended in either territorial waters or exclusive economic zones.
04:00UTC 05th May to 06:40UTC 05th May 2010 (Guam, U.S.A.)
12:00UTC 08th May to 05:30UTC 09th May 2010 (Federated States of Micronesia)
22:58UTC 11th May to 07:50UTC 13th May 2010 (Republic of Palau)

Table 5.22.1-1 Absolute gravity table

No	Date	UTC	Port	Absolute Gravity [mGal]	Sea Level [cm]	Draft [cm]	Gravity at Sensor *1 [mGal]	L&R*2 Gravity [mGal]
#1	Apr/5	06:26	Sekinehama	980,371.93	310	655	980,372.94	12,635.71
#2	Jun/30	03:03	Moji	979,672.01	203	570	979,672.46	11,938.49

*1: Gravity at Sensor = Absolute Gravity + Sea Level*0.3086/100 + (Draft-530)/100*0.0431
*2: LaCoste and Romberg air-sea gravity meter S-116

Differential	G at sensor	L&R value
#1 －#2	-700.48 mGal ---(a)	-697.22 mGal ---(b)
L&R drift value (b)-(a)	3.26 mGal /	85.86 days
Daily drift ratio	0.0380 mGal/day	

5.22.2 Sea Surface Three-Component Magnetometer

(1) Personnel

Takeshi MATSUMOTO	(University of the Ryukyus) : Principal Investigator (Not on-board)
Souichiro SUEYOSHI	(Global Ocean Development Inc., GODI)
Harumi OTA	(GODI)
Asuka DOI	(GODI)
Ryo OHYAMA	(MIRAI Crew)

(2) Introduction

Measurement of magnetic force on the sea is required for the geophysical investigations of marine magnetic anomaly caused by magnetization in upper crustal structure. We measured geomagnetic field using a three-component magnetometer during the MR10-03 cruise from 5th May 2010 to 28th June 2010.

(3) Principle of ship-board geomagnetic vector measurement

The relation between a magnetic-field vector observed on-board, **H**ob, (in the ship's fixed coordinate system) and the geomagnetic field vector, **F**, (in the Earth's fixed coordinate system) is expressed as:

$$\mathbf{H}ob = \widetilde{\mathbf{A}}\ \widetilde{\mathbf{R}}\ \widetilde{\mathbf{P}}\ \widetilde{\mathbf{Y}}\ \mathbf{F} + \mathbf{H}p \qquad \text{(a)}$$

where $\widetilde{\mathbf{R}}$, $\widetilde{\mathbf{P}}$ and $\widetilde{\mathbf{Y}}$ are the matrices of rotation due to roll, pitch and heading of a ship, respectively. $\widetilde{\mathbf{A}}$ is a 3 x 3 matrix which represents magnetic susceptibility of the ship, and **H**p is a magnetic field vector produced by a permanent magnetic moment of the ship's body. Rearrangement of Eq. (a) makes

$$\widetilde{\mathbf{R}}\ \mathbf{H}ob + \mathbf{H}bp = \widetilde{\mathbf{R}}\ \widetilde{\mathbf{P}}\ \widetilde{\mathbf{Y}}\ \mathbf{F} \qquad \text{(b)}$$

where $\widetilde{\mathbf{R}} = \widetilde{\mathbf{A}}^{-1}$, and $\mathbf{H}bp = -\widetilde{\mathbf{R}}\ \mathbf{H}p$. The magnetic field, **F**, can be obtained by measuring $\widetilde{\mathbf{R}}$, $\widetilde{\mathbf{P}}$, $\widetilde{\mathbf{Y}}$ and **H**ob, if $\widetilde{\mathbf{R}}$ and **H**bp are known. Twelve constants in $\widetilde{\mathbf{R}}$ and **H**bp can be determined by measuring variation of **H**ob with $\widetilde{\mathbf{R}}$, $\widetilde{\mathbf{P}}$ and $\widetilde{\mathbf{Y}}$ at a place where the geomagnetic field, **F**, is known.

(4) Instruments on R/V MIRAI

A shipboard three-component magnetometer system (Tierra Tecnica SFG1214) is equipped on-board R/V MIRAI. Three-axes flux-gate sensors with ring-cored coils are fixed on the fore mast. Outputs from the sensors are digitized by a 20-bit A/D converter (1 nT/LSB), and sampled at 8 times per second. Ship's heading, pitch, and roll are measured by the Inertial Navigation System (INS) for controlling attitude of a Doppler radar. Ship's position (GPS) and speed data are taken from LAN every second.

(5) Data Archives

These data obtained in this cruise will be submitted to the Data Integration and Analysis Group (DIAG) of JAMSTEC.

(6) Remarks

1) Following periods, data acquisition was suspended in either territorial waters or exclusive economic zones.
   04:00UTC 05th May to 06:40UTC 05th May 2010 (Guam, U.S.A.)
   12:00UTC 08th May to 05:30UTC 09th May 2010 (Federated States of Micronesia)
   22:58UTC 11th May to 07:50UTC 13th May 2010 (Republic of Palau)

2) For calibration of the ship’s magnetic effect, we made a “figure-eight” turn (a pair of clockwise and anti-clockwise rotation). This calibration was carried out as below.
   09:03UTC 13th May. 2010 to 09:30UTC 13th May. 2010 (07-21N, 133-58E)
   01:21UTC 25th Jun. 2010 to 01:48UTC 25th Jun. 2010 (20-29N, 136-02E)

5.22.3 Swath Bathymetry

(1) Personnel

Takeshi MATSUMOTO	(University of the Ryukyus) : Principal Investigator (Not on-board)
Souichiro SUEYOSHI	(Global Ocean Development Inc., GODI)
Harumi OTA	(GODI)
Asuka DOI	(GODI)
Ryo OHYAMA	(MIRAI Crew)

(2) Introduction

R/V MIRAI is equipped with a Multi narrow Beam Echo Sounding system (MBES), SEABEAM 2112 (SeaBeam Instruments Inc.). The objective of MBES is collecting continuous bathymetric data along ship's track to make a contribution to geological and geophysical investigations and global datasets.

(3) Data Acquisition

The "SEABEAM 21112" on R/V MIRAI was used for bathymetry mapping during the MR10-03 cruise from 5th May 2010 to 28th June 2010. To get accurate sound velocity of water column for ray-path correction of acoustic multibeam, we used Surface Sound Velocimeter (SSV) data to get the sea surface (6.2m) sound velocity, and the deeper depth sound velocity profiles were calculated by temperature and salinity profiles from CTD data by the equation in Del Grosso (1974) during the cruise. Table 5.22.3-1 shows system configuration and performance of SEABEAM 2112.004 system.

Table 5.22.3-1 System configuration and performance

SEABEAM 2112 (12 kHz system)	
Frequency:	12 kHz
Transmit beam width:	2 degree
Transmit power:	20 kW
Transmit pulse length:	3 to 20 msec.
Depth range:	100 to 11,000 m
Beam spacing:	1 degree athwart ship
Swath width:	150 degree (max) 120 degree to 4,500 m 100 degree to 6,000 m 90 degree to 11,000 m
Depth accuracy:	Within < 0.5% of depth or +/-1m, whichever is greater, over the entire swath. (Nadir beam has greater accuracy; typically within < 0.2% of depth or +/-1m, whichever is greater)

(4) Preliminary Results

The results will be published after primary processing.

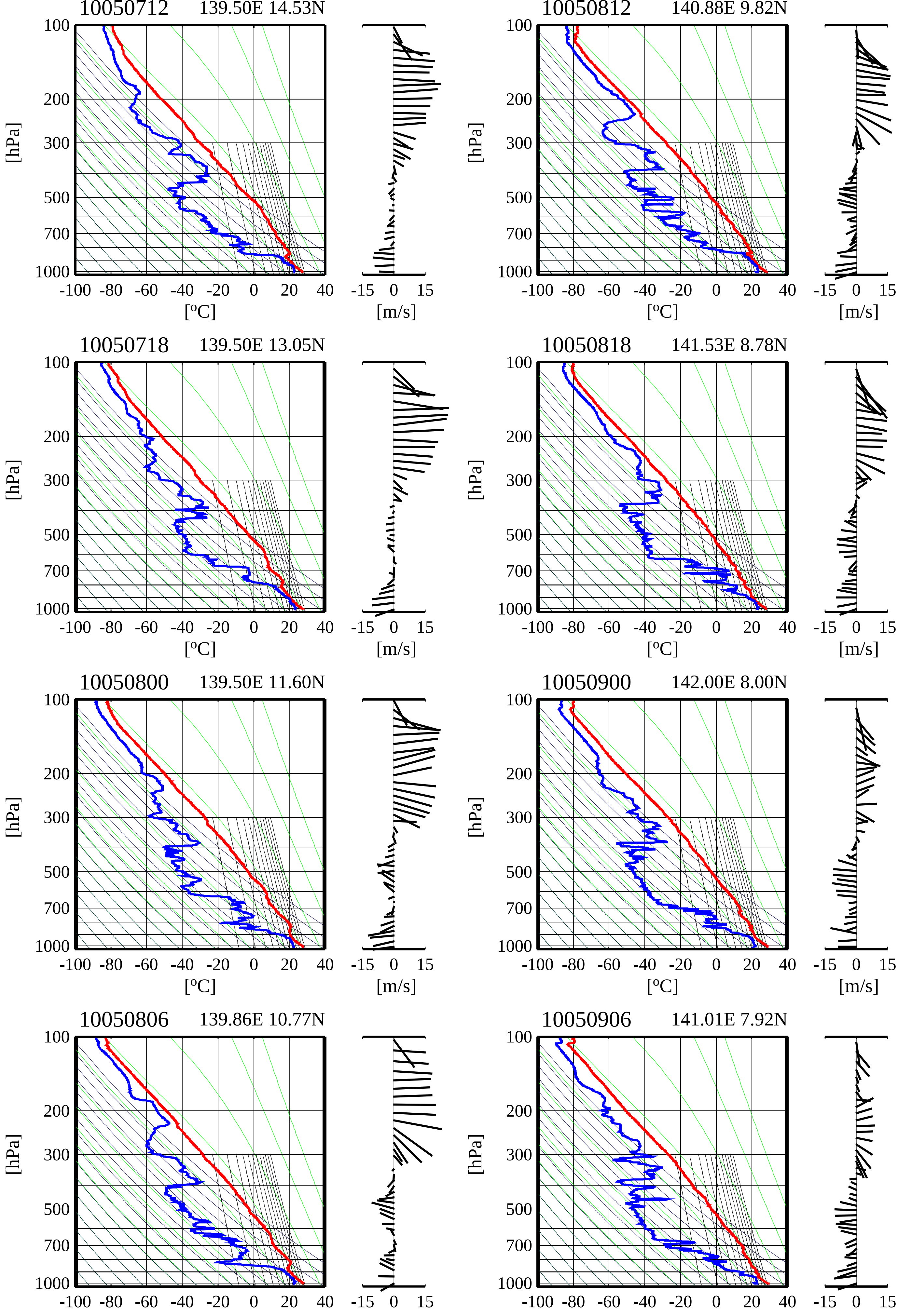
(5) Data Archives

Bathymetric data obtained during this cruise will be submitted to the Data Integration and Analysis Group (DIAG) in JAMSTEC, and will be archived there.

(6) Remarks

1) Following periods, data acquisition was suspended in either territorial waters or exclusive economic zones.
   04:00UTC 05th May to 06:40UTC 05th May 2010 (Guam, U.S.A.)
   12:00UTC 08th May to 05:30UTC 09th May 2010 (Federated States of Micronesia)
   22:58UTC 11th May to 07:50UTC 13th May 2010 (Republic of Palau)

Appendix-A: Emagrams from Radiosonde Observations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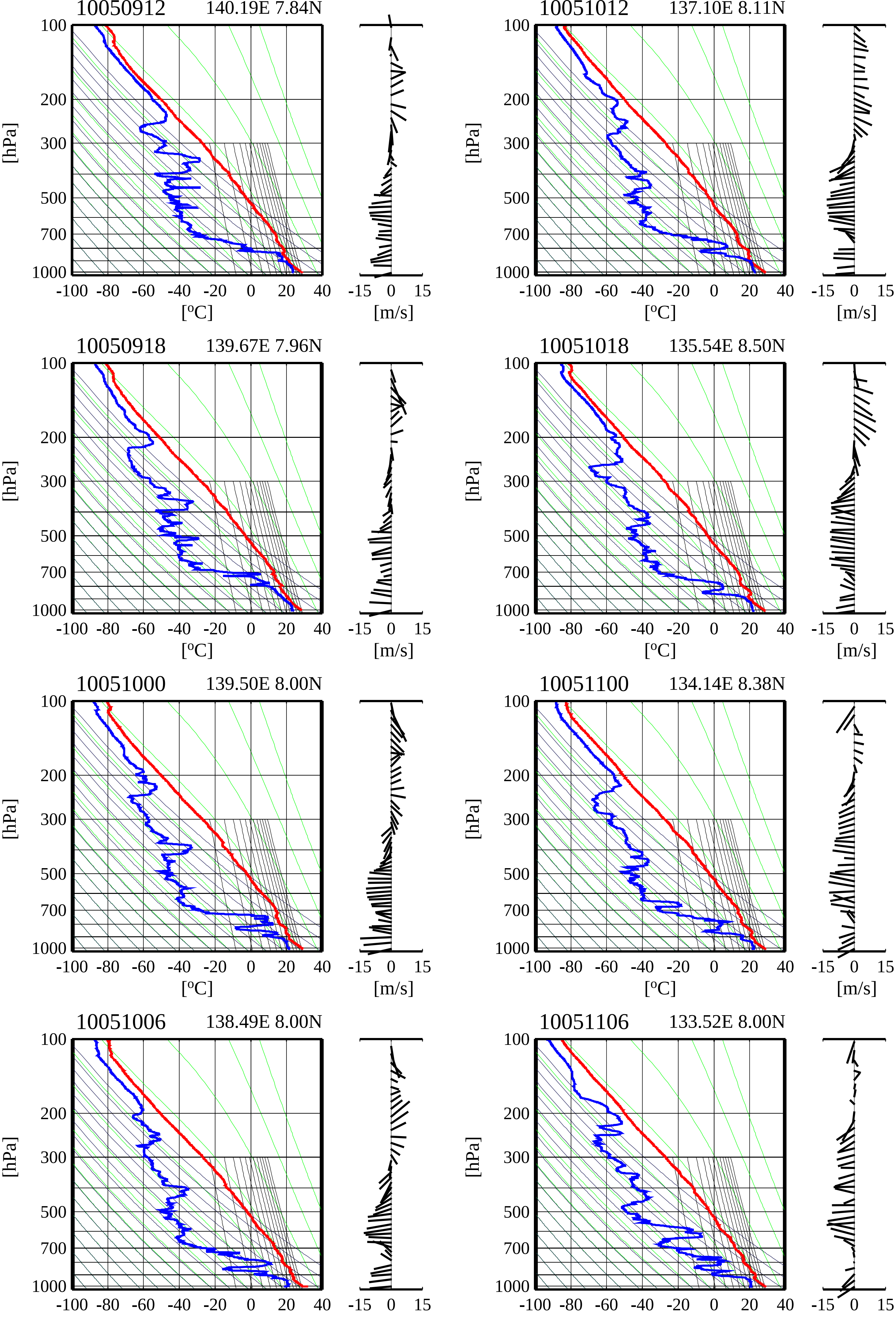
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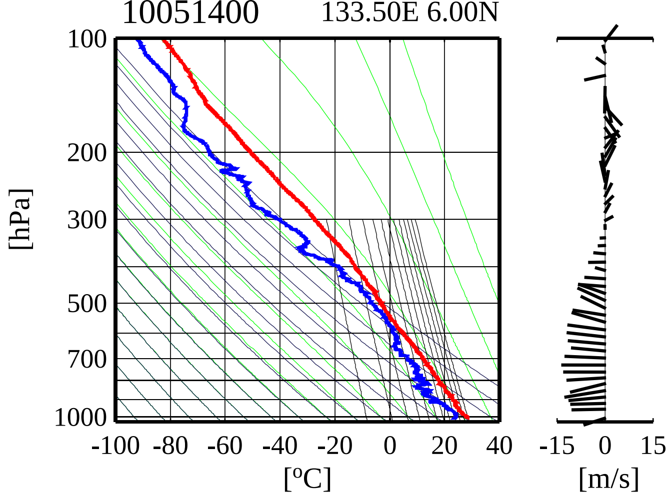
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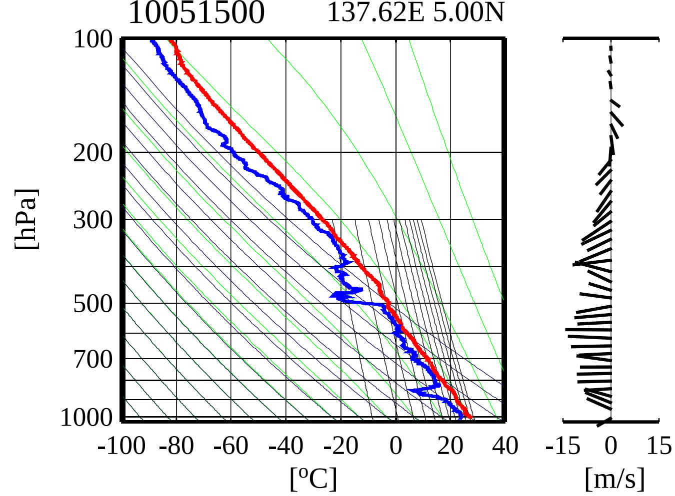
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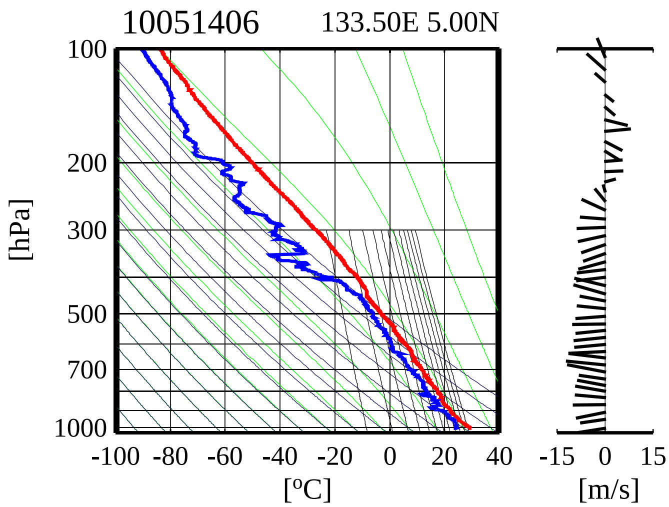
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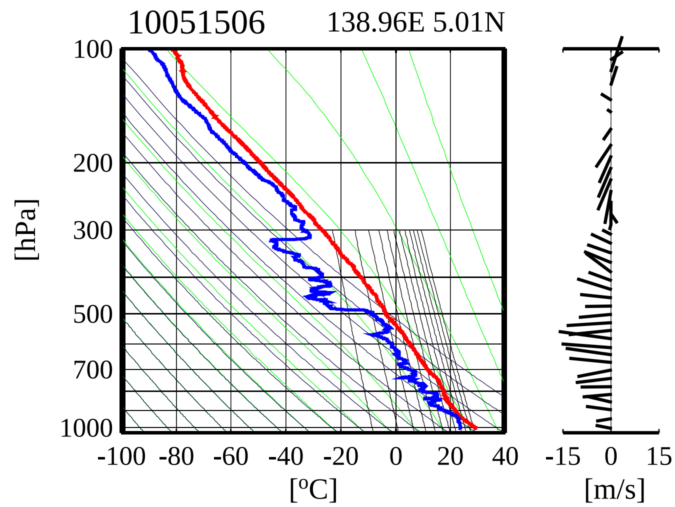
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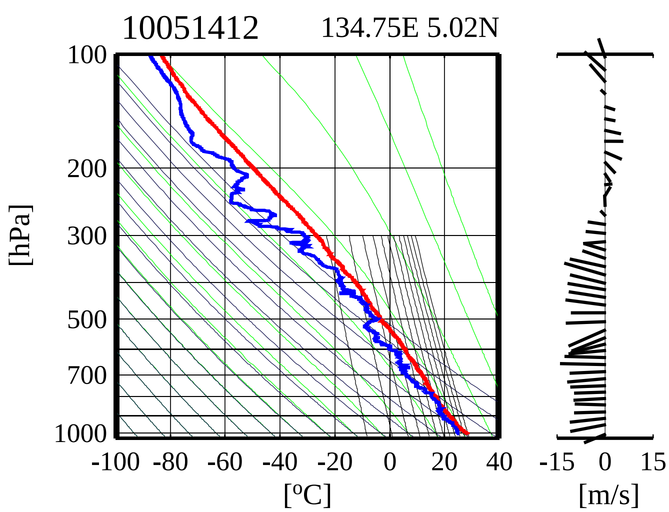
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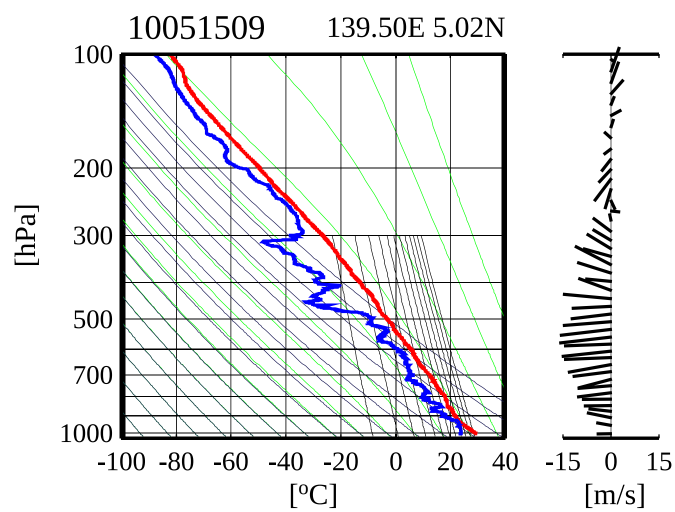
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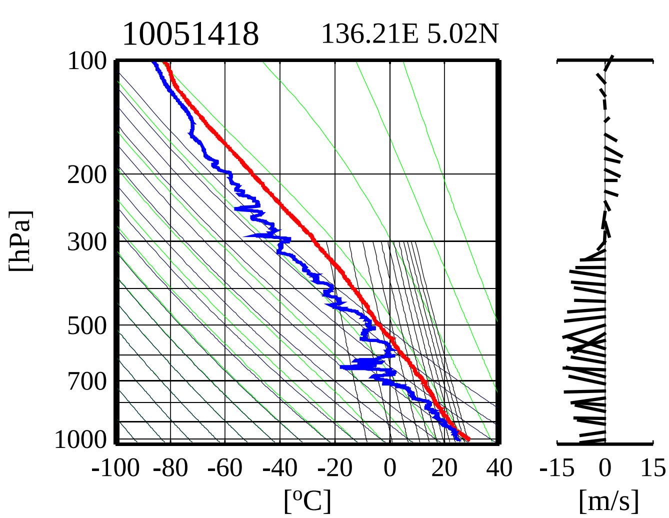
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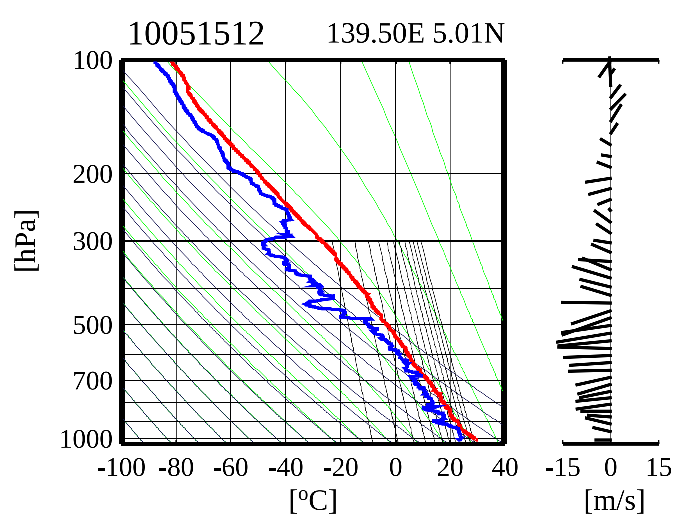
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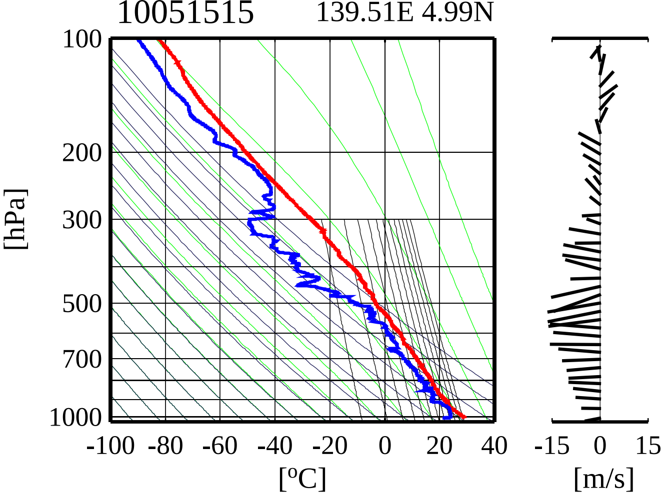
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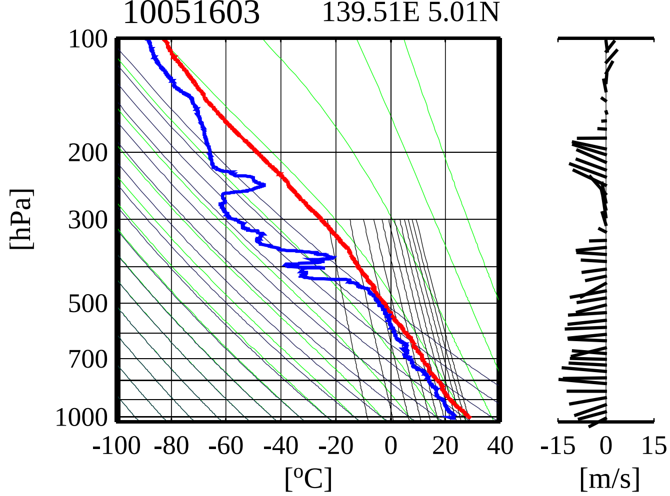
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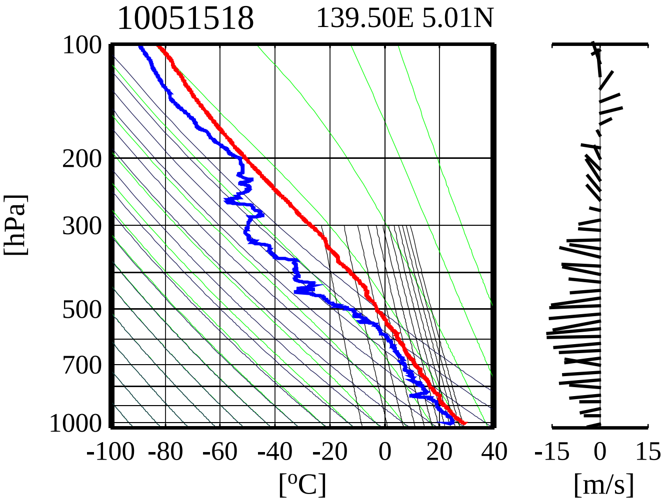
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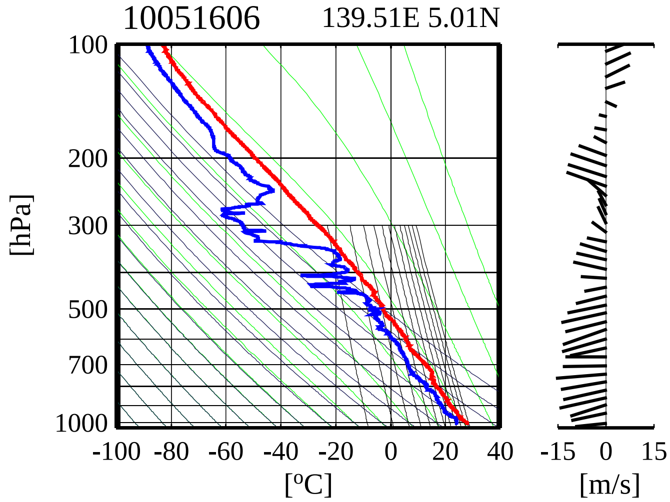
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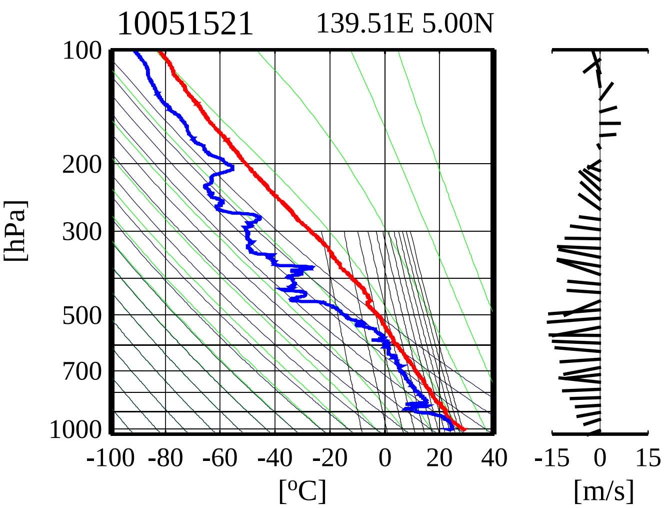
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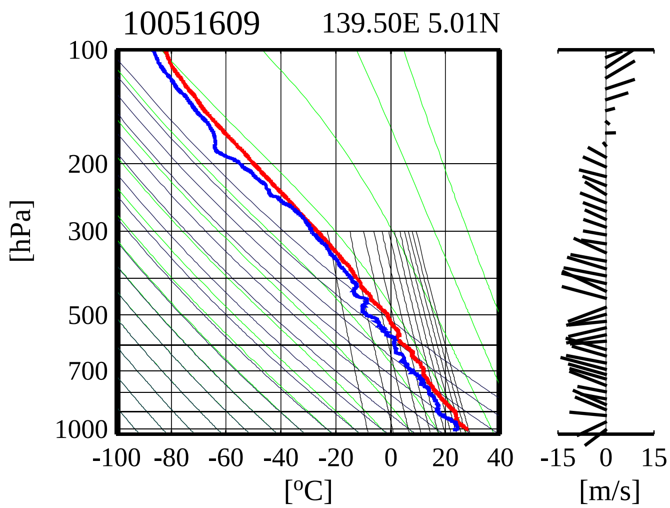
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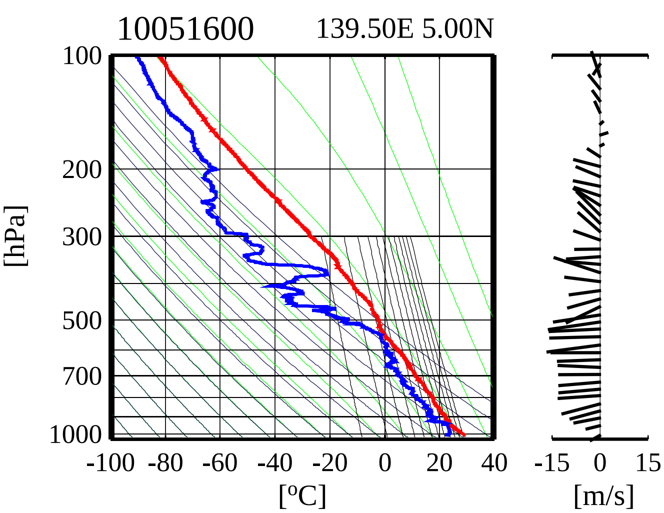
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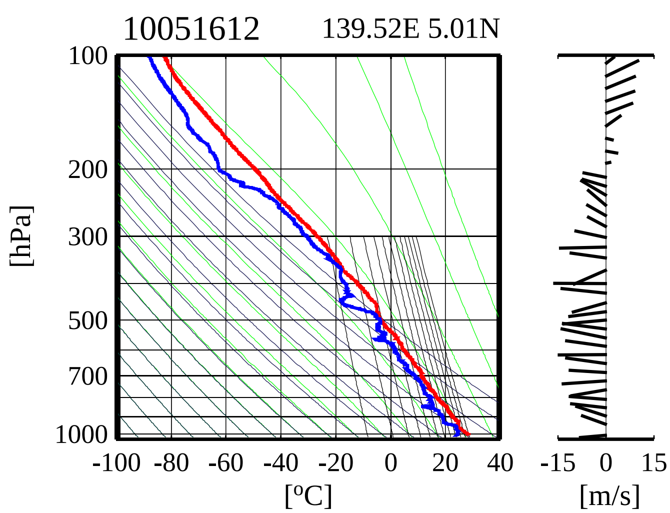
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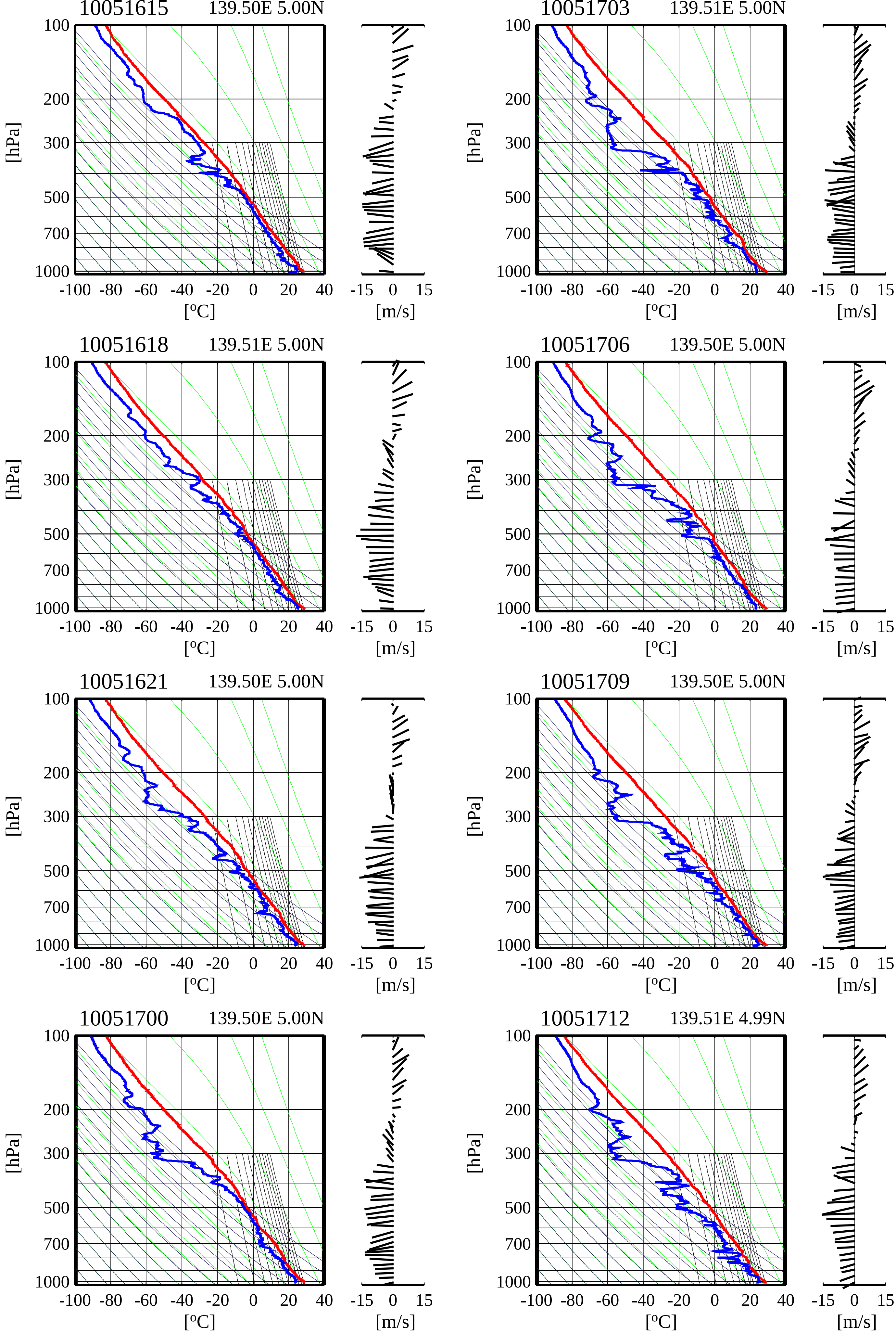
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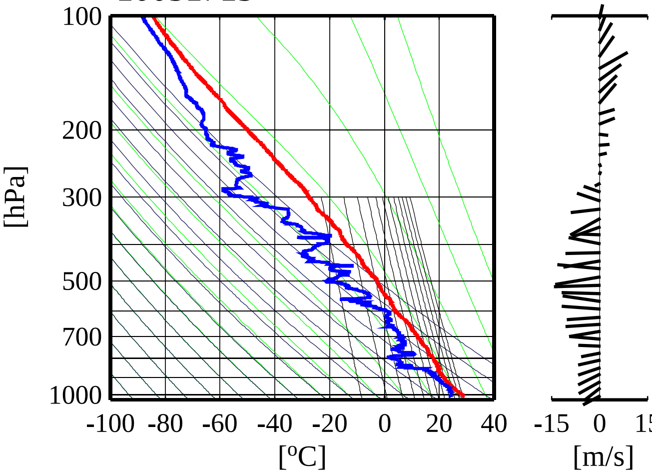

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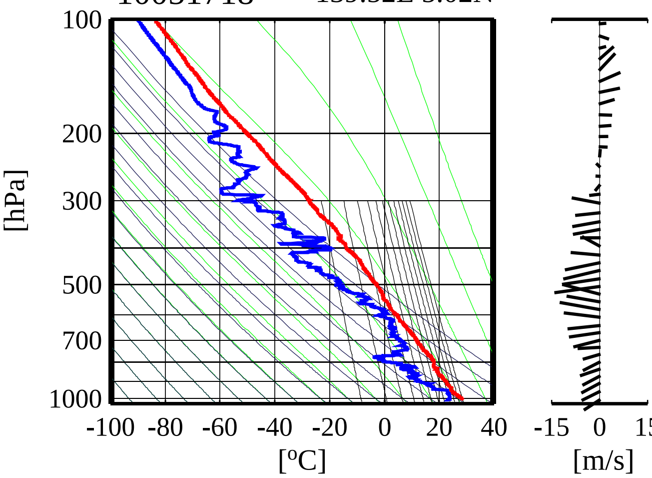

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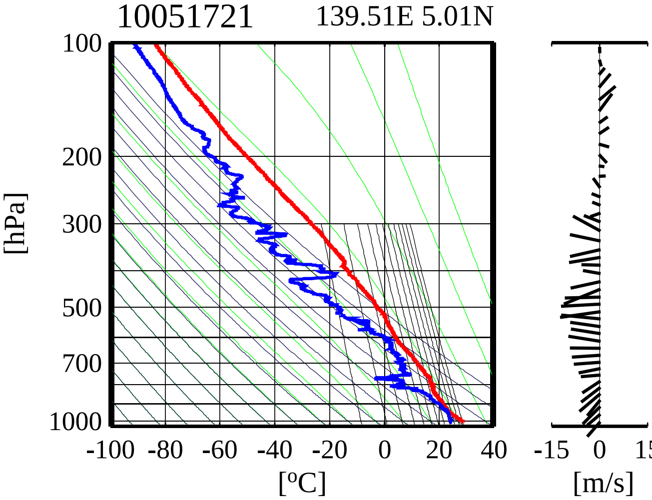

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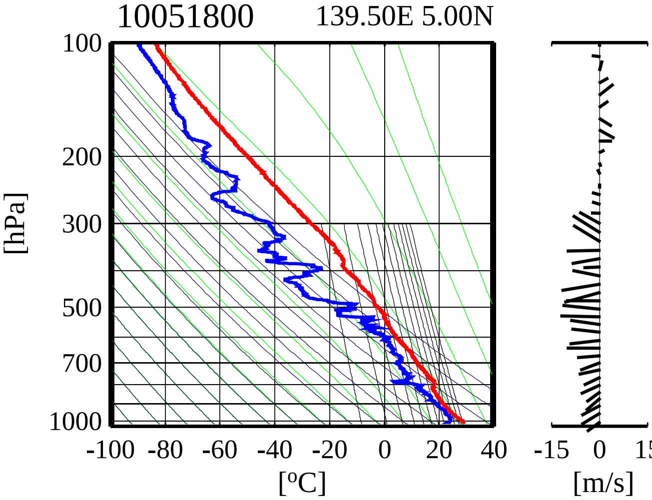

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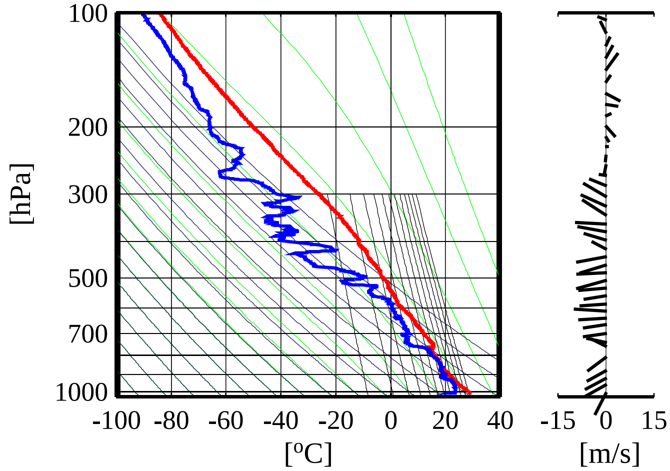

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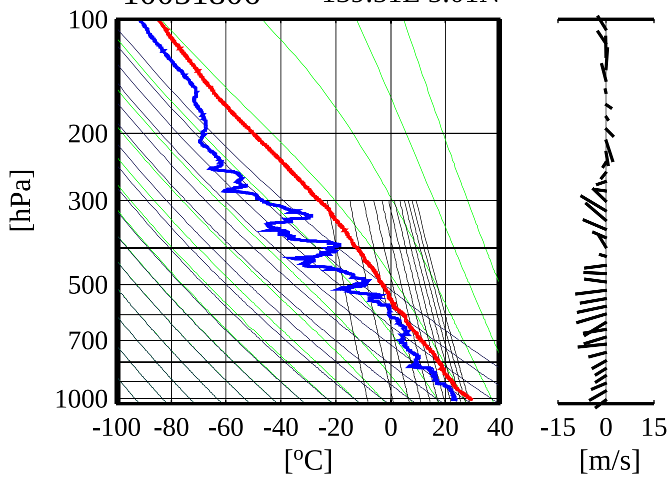

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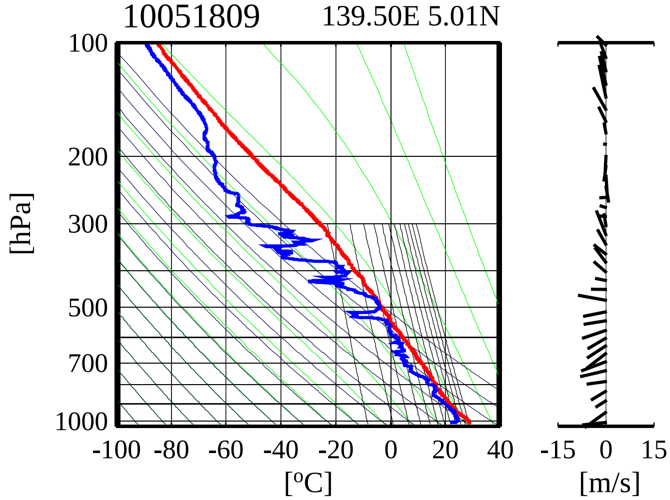

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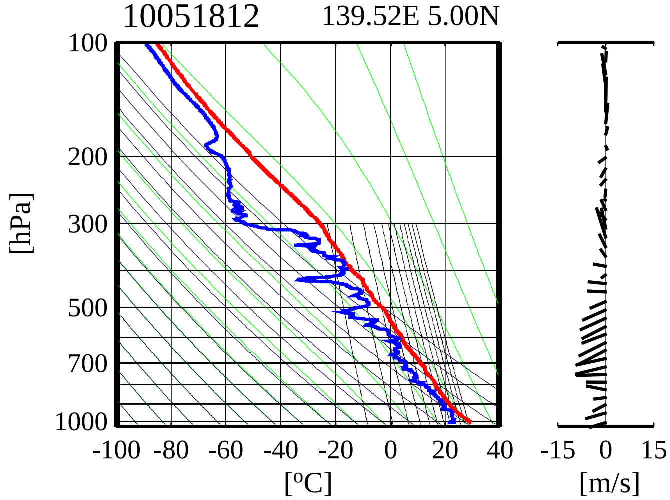

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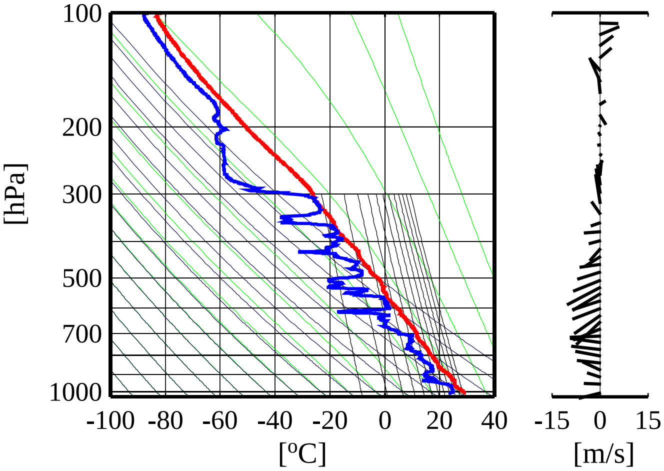

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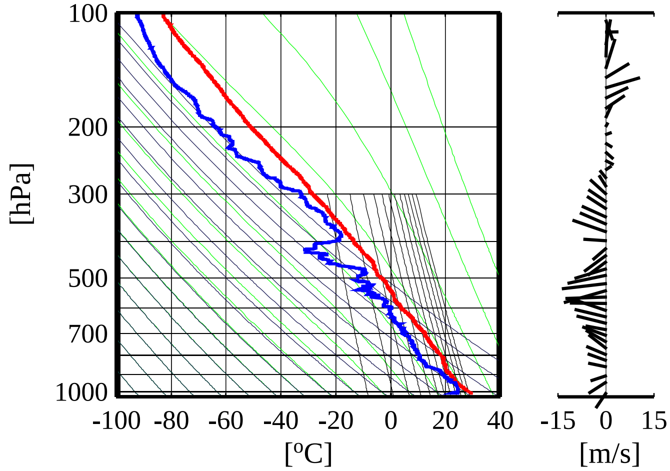

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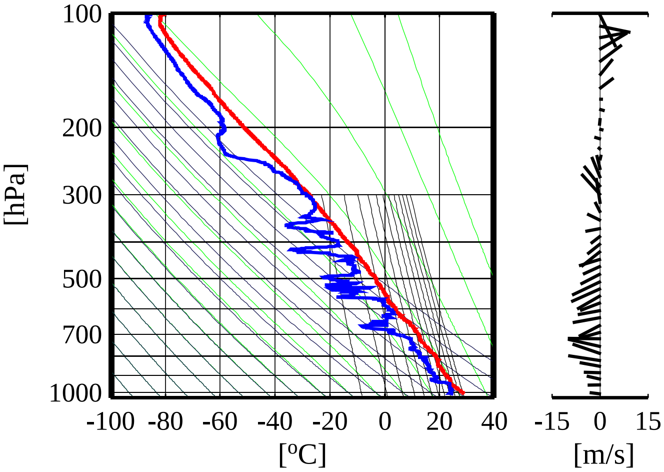

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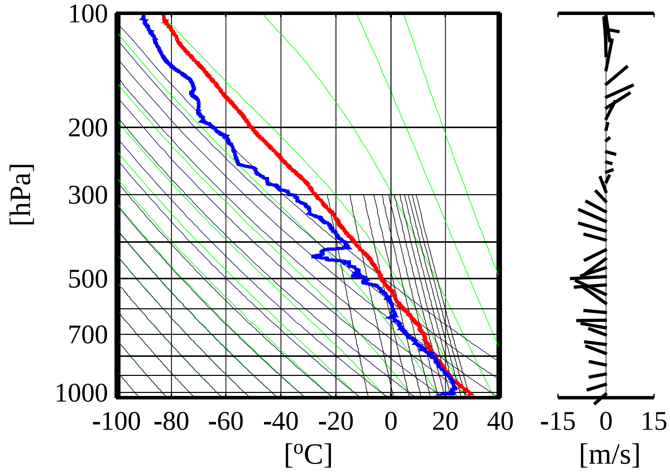

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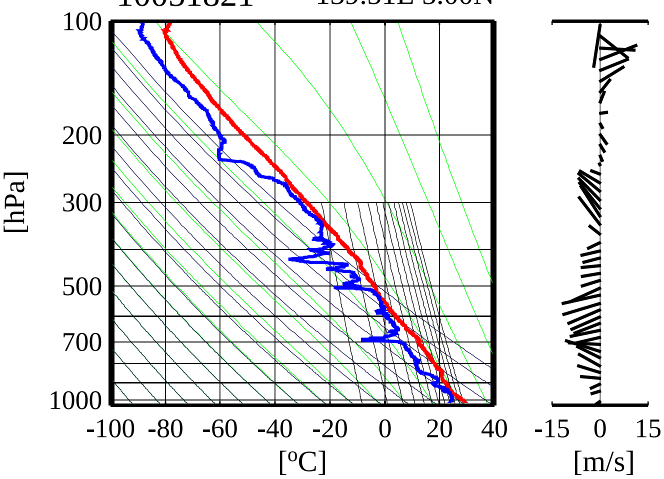

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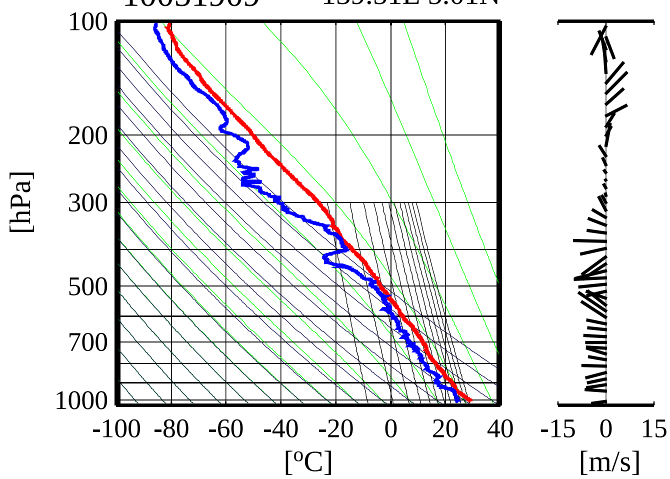

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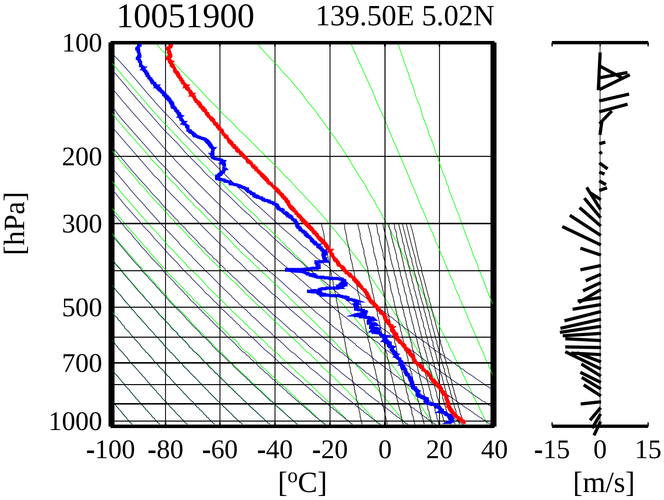

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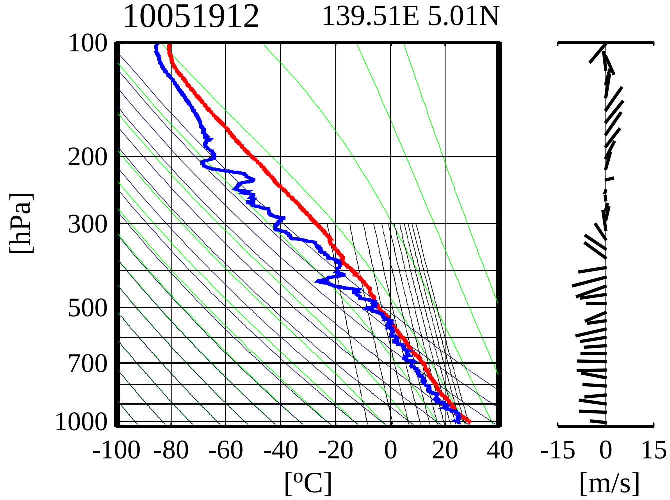

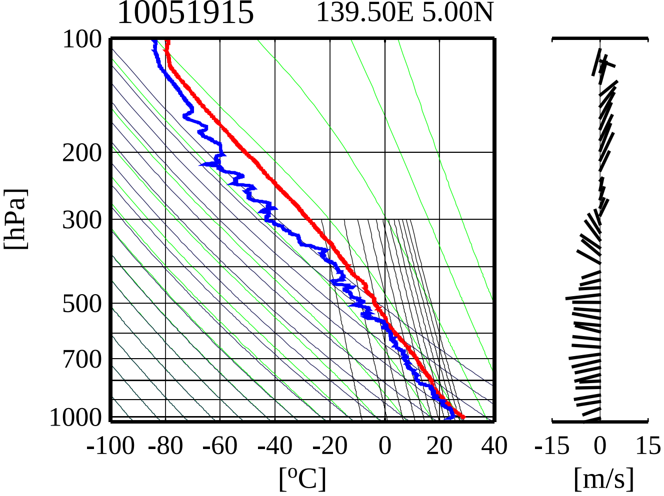
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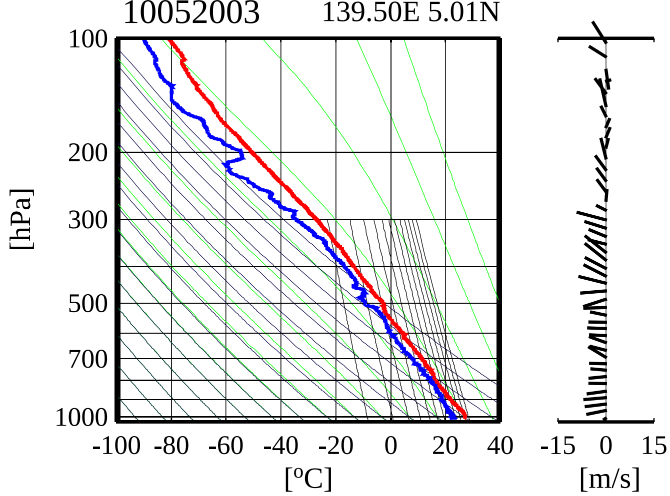
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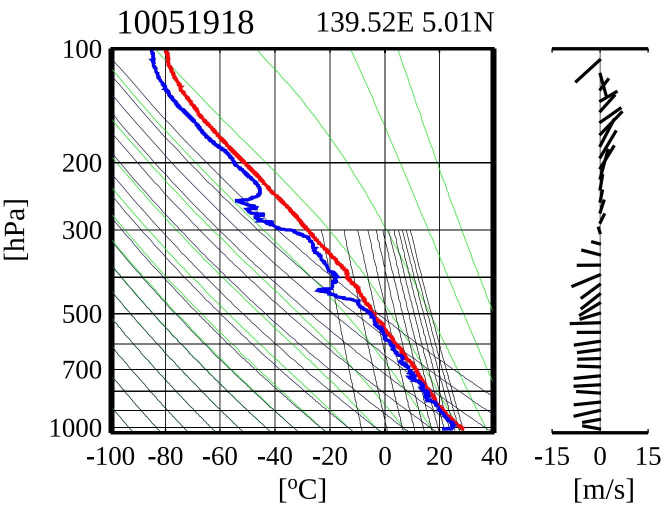
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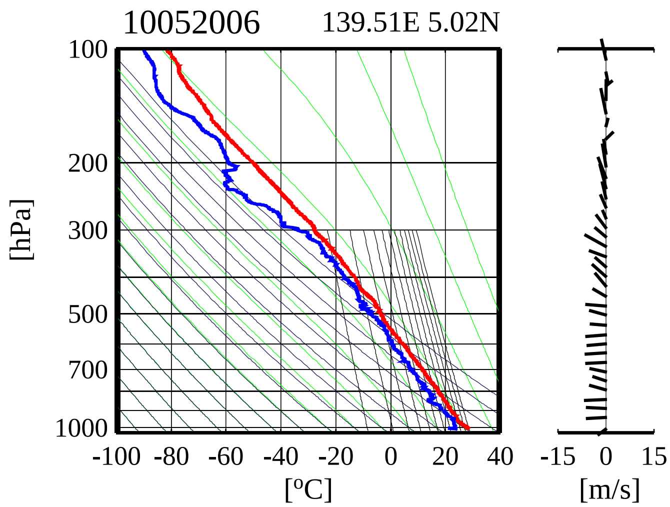
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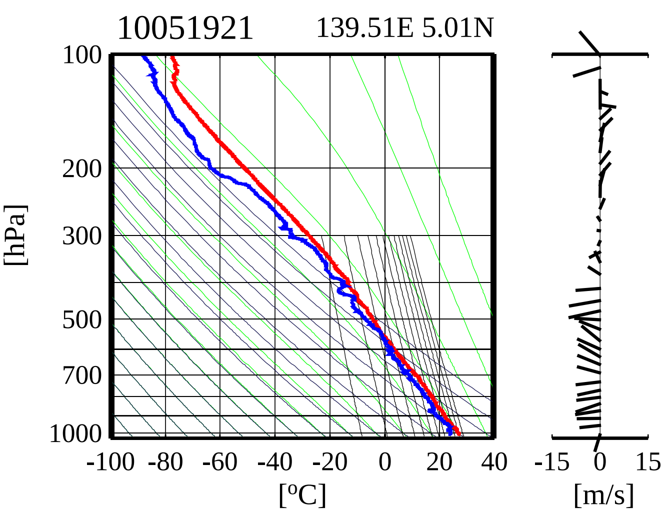
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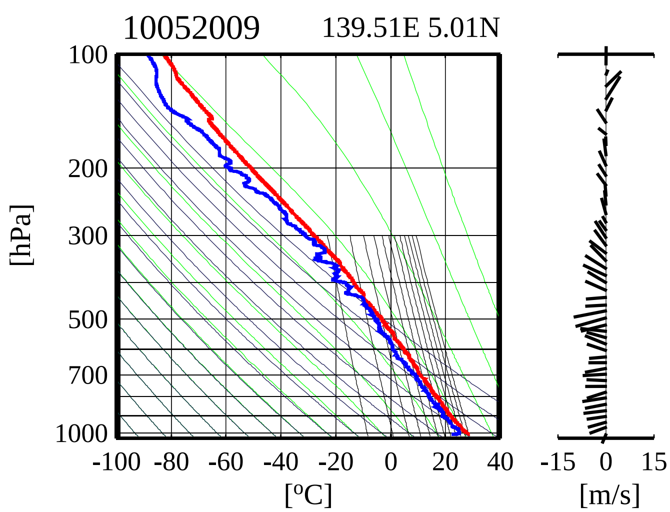
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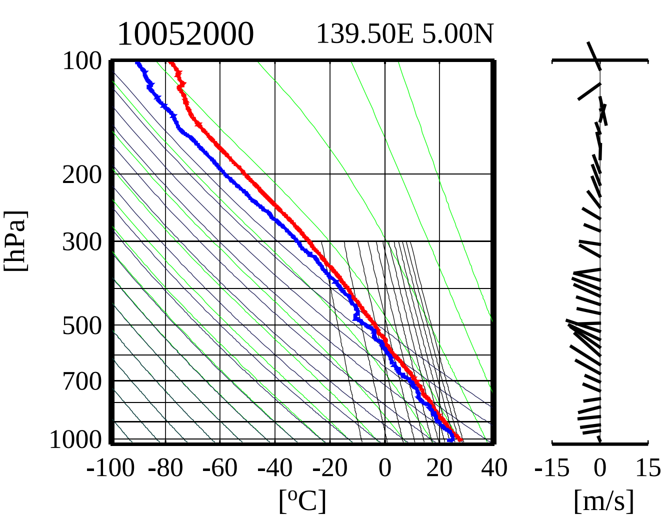
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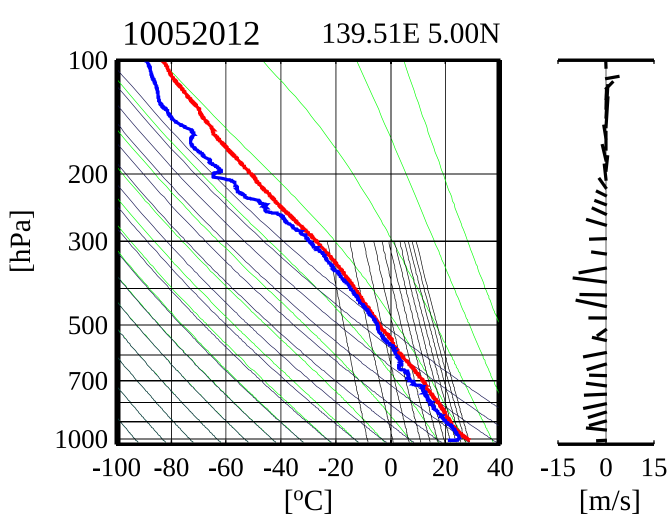
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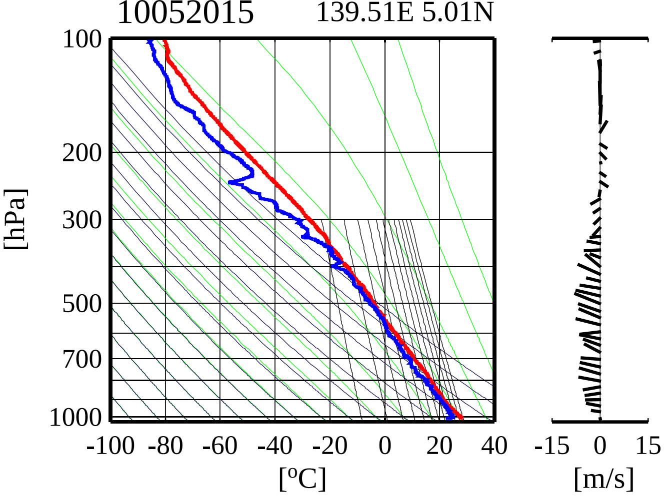
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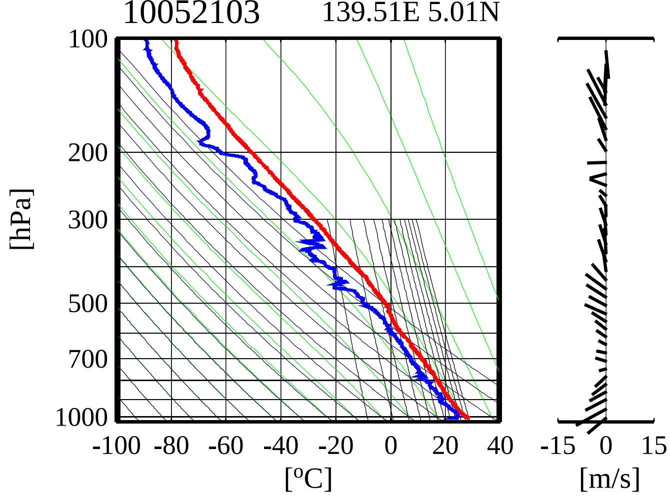
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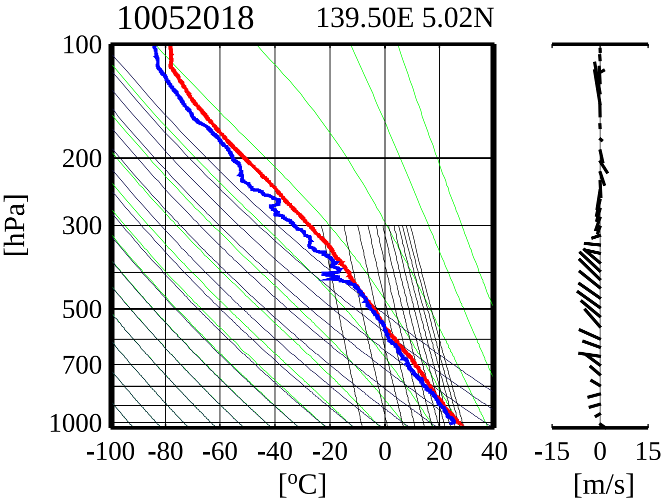
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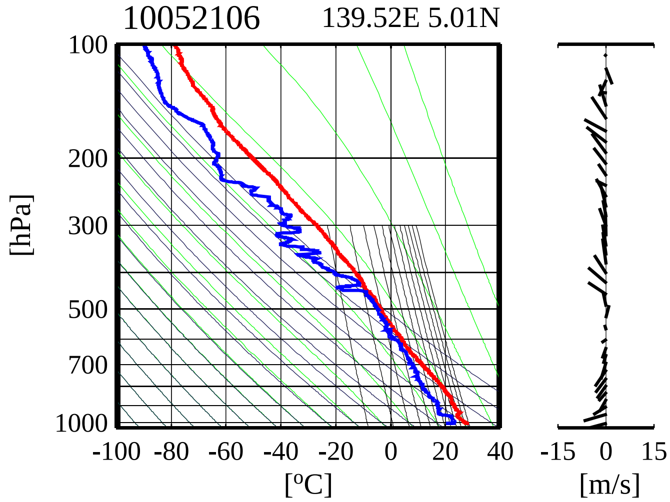
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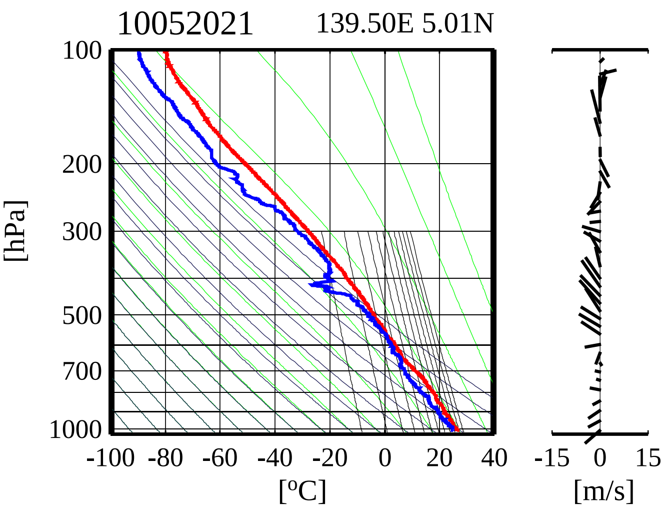
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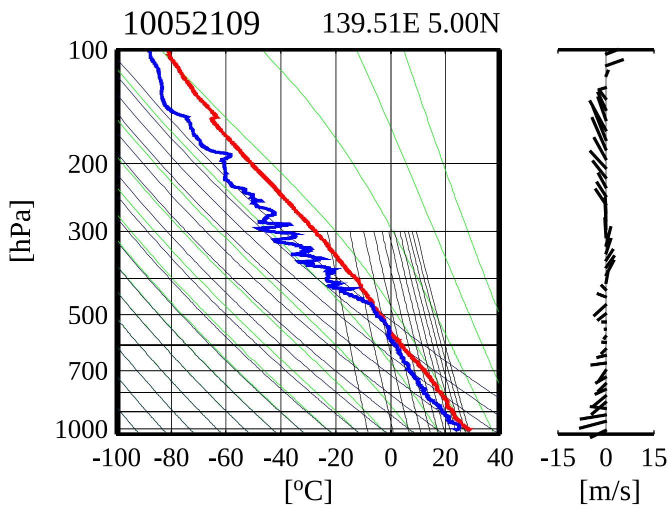
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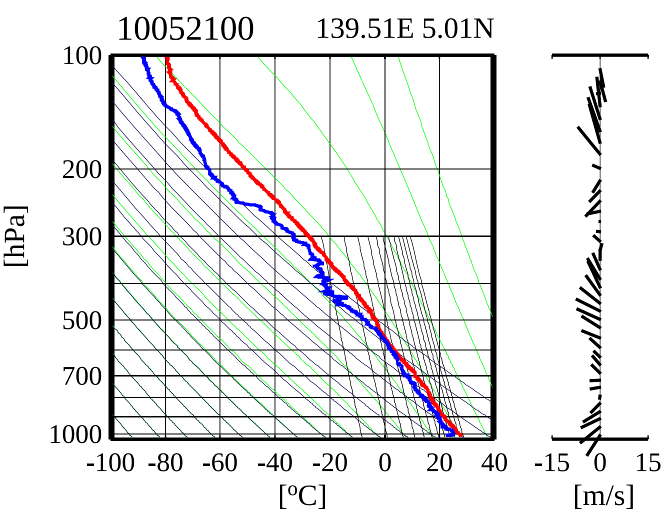
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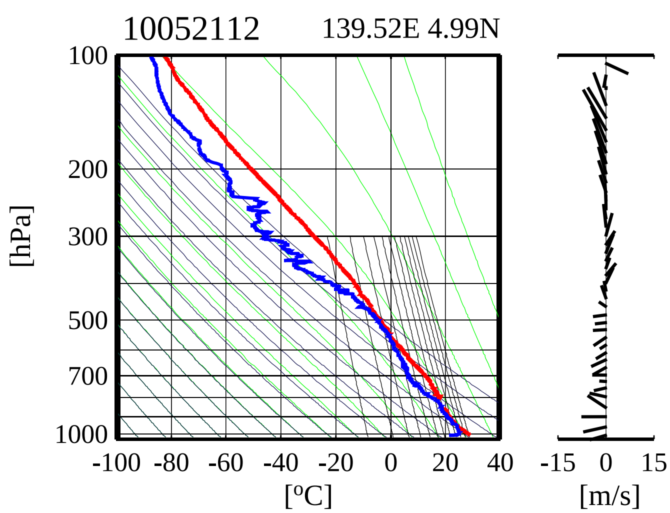
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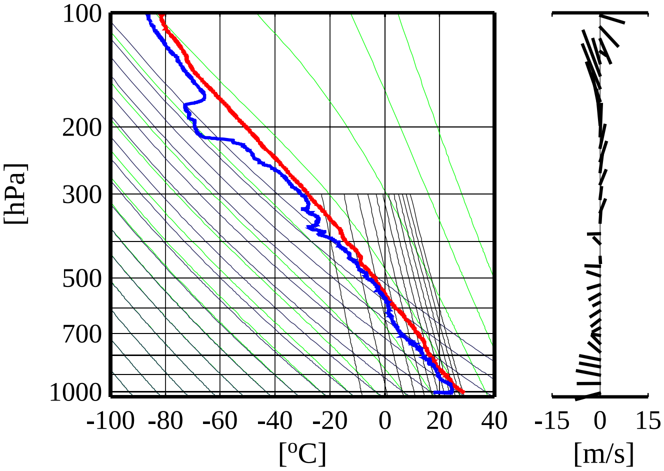

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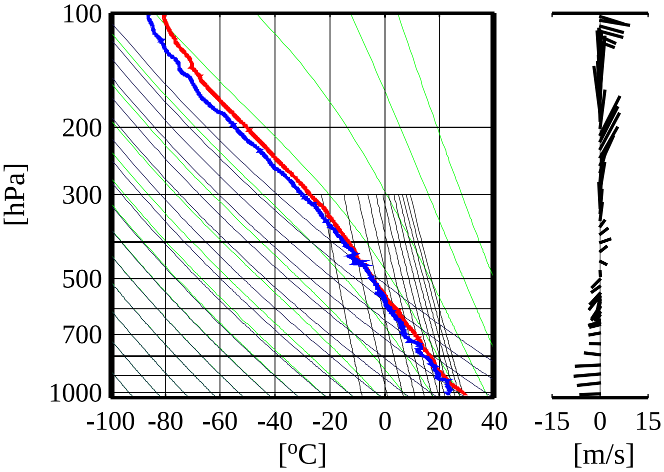

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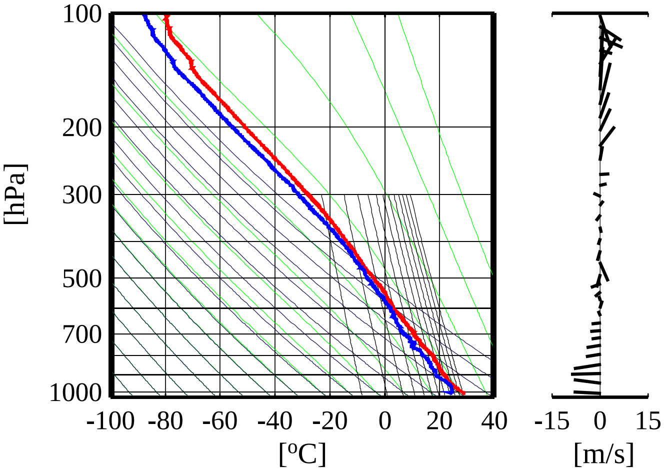

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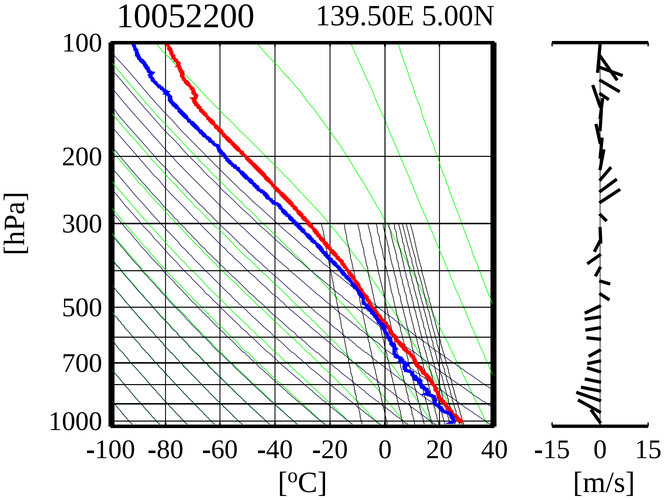

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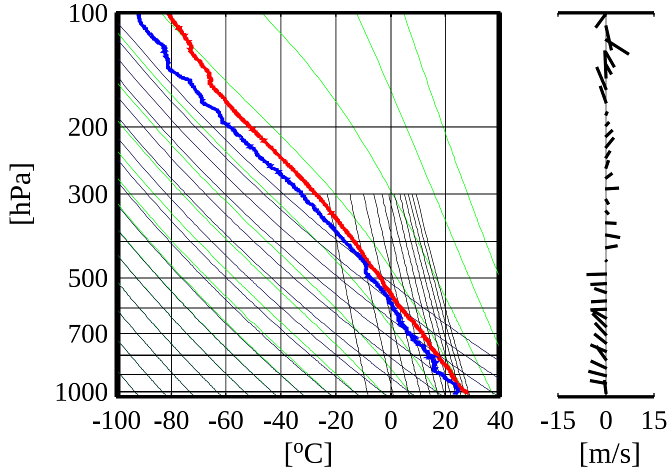

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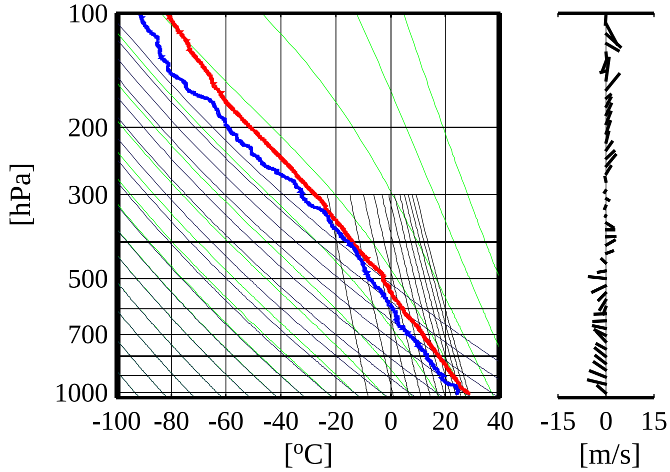

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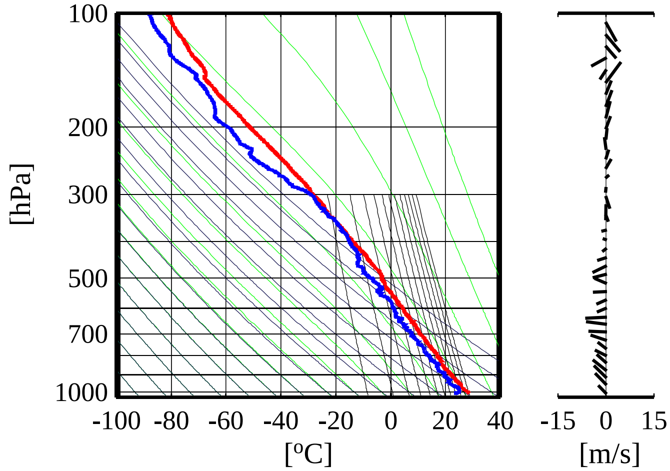

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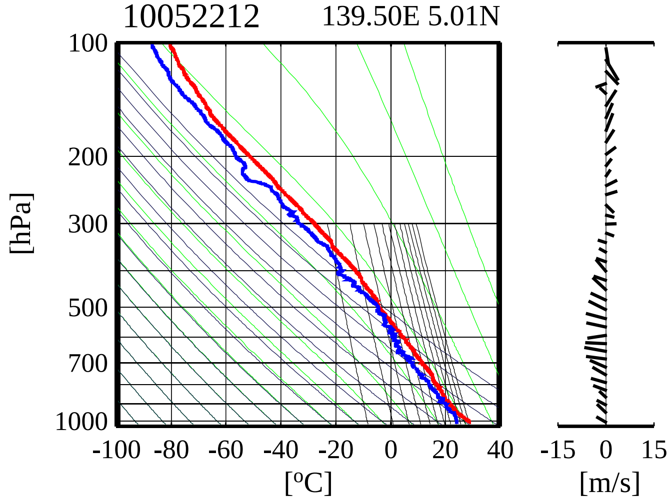

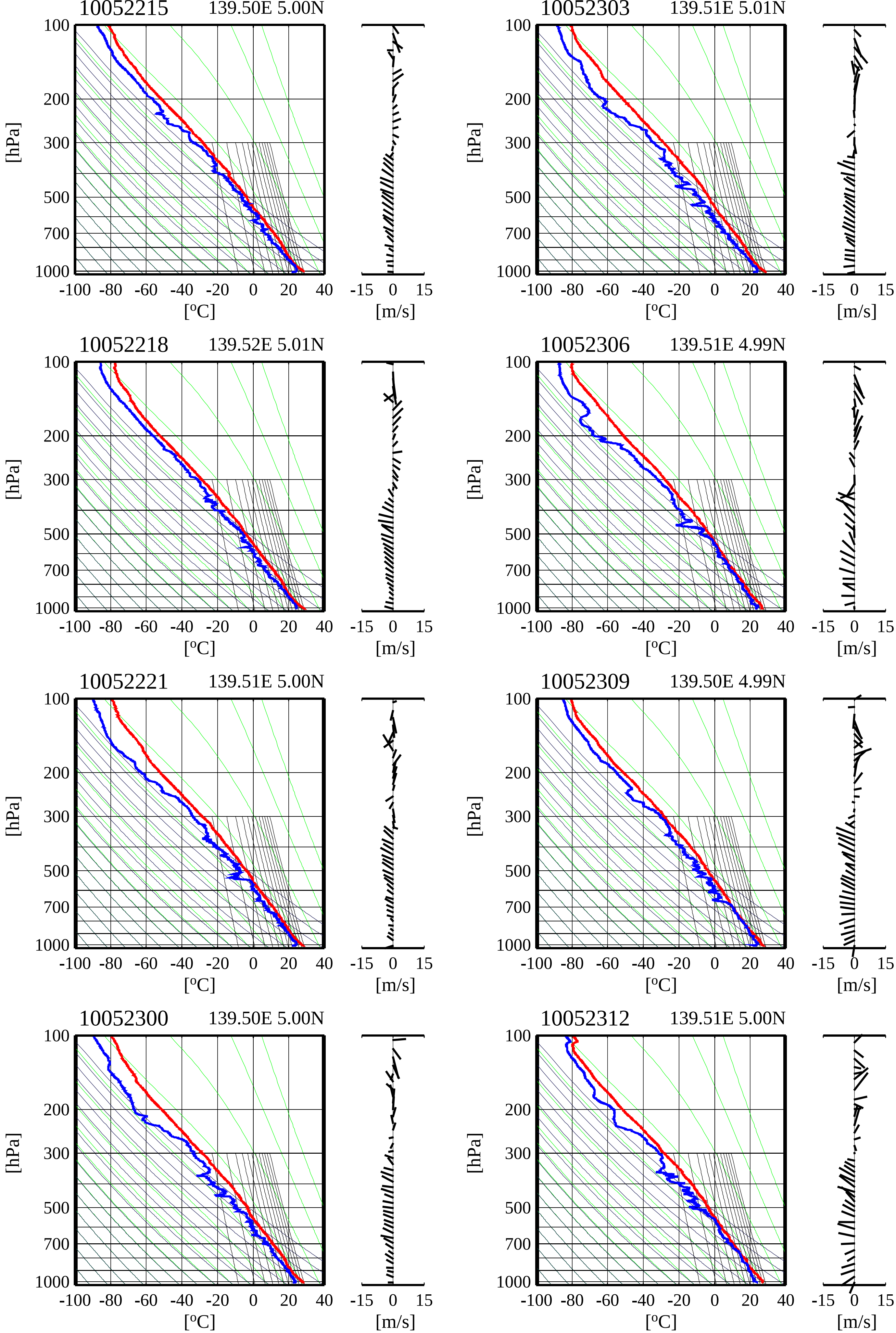
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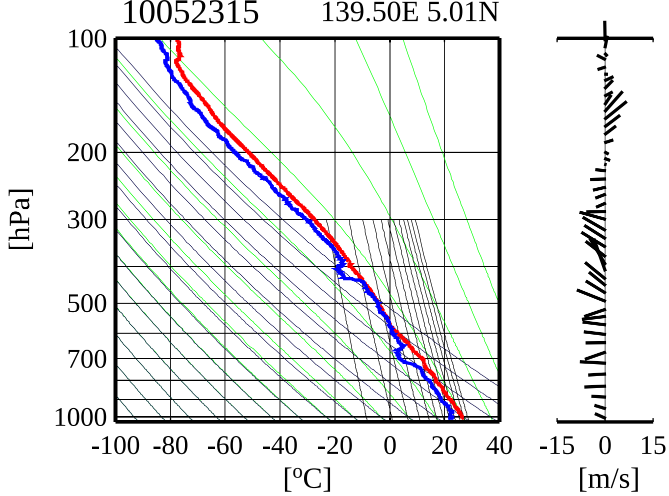
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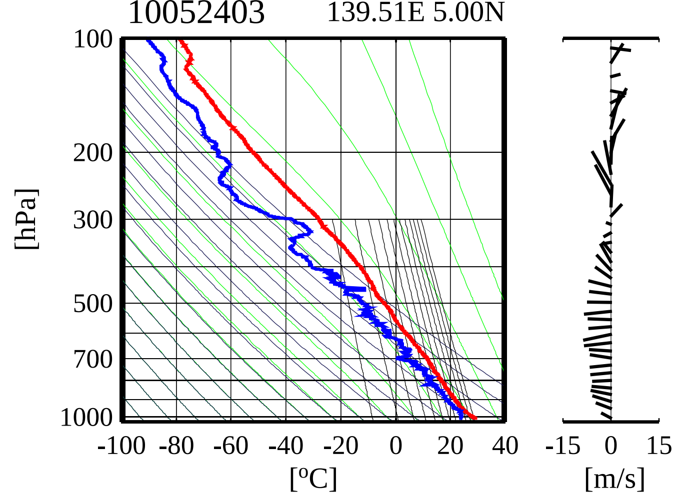
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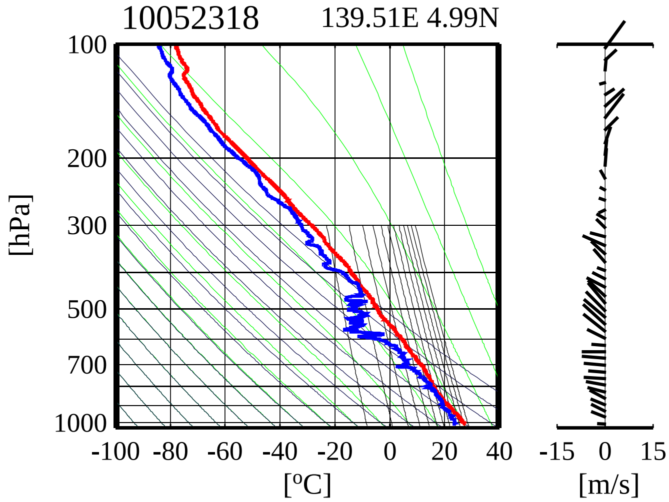
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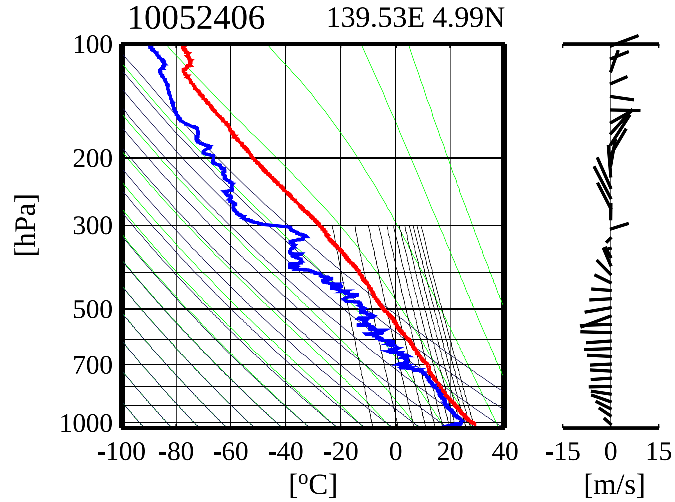
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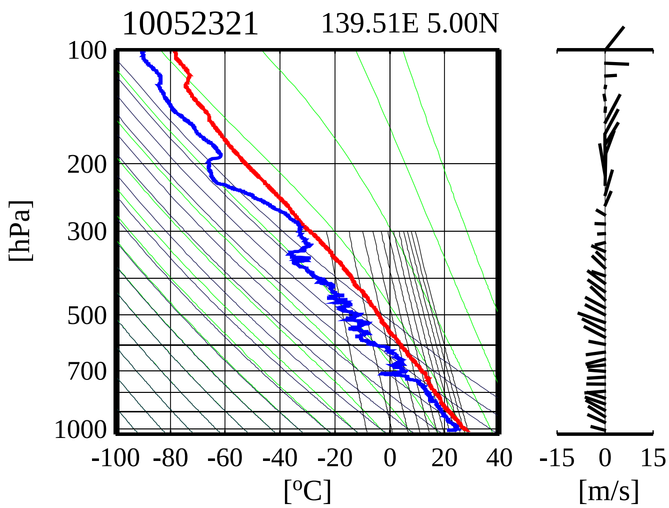
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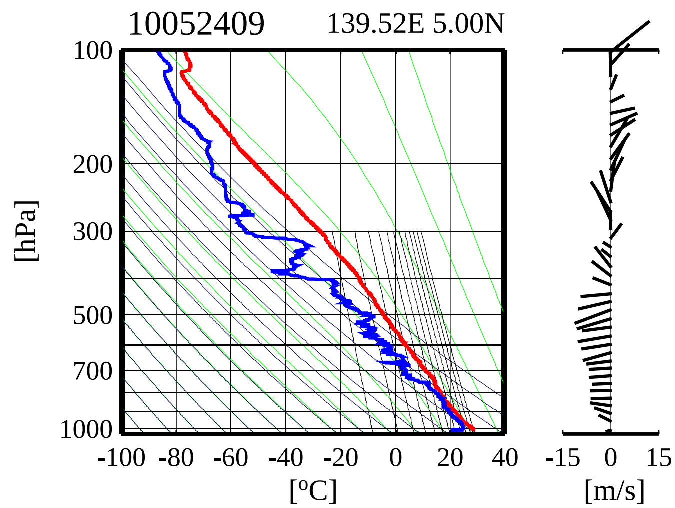
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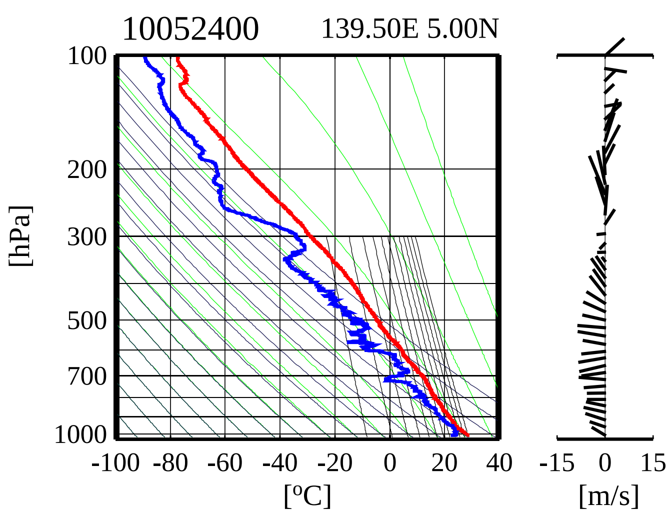
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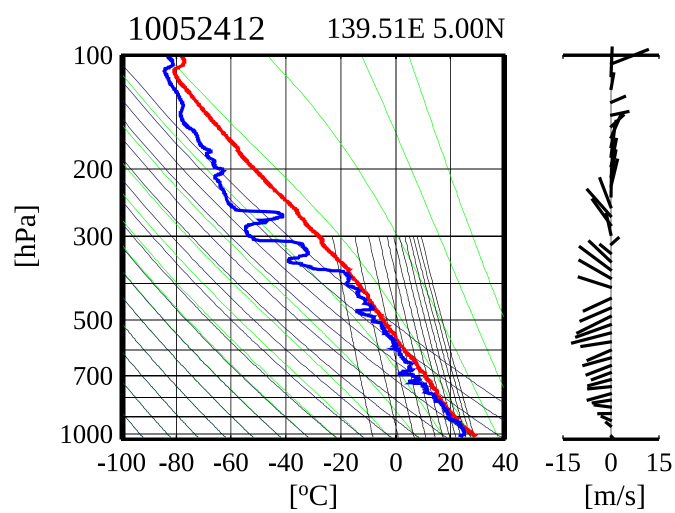
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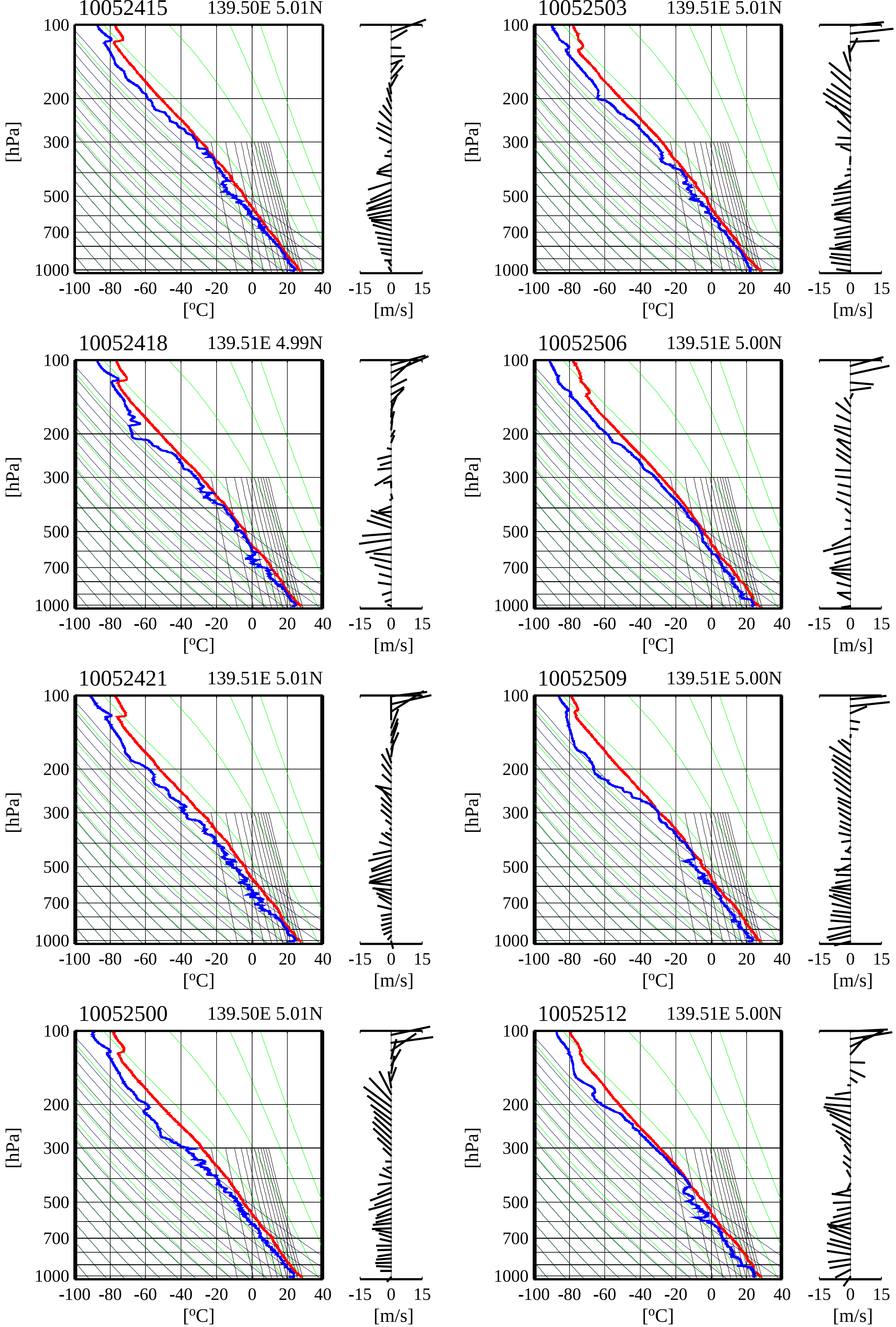
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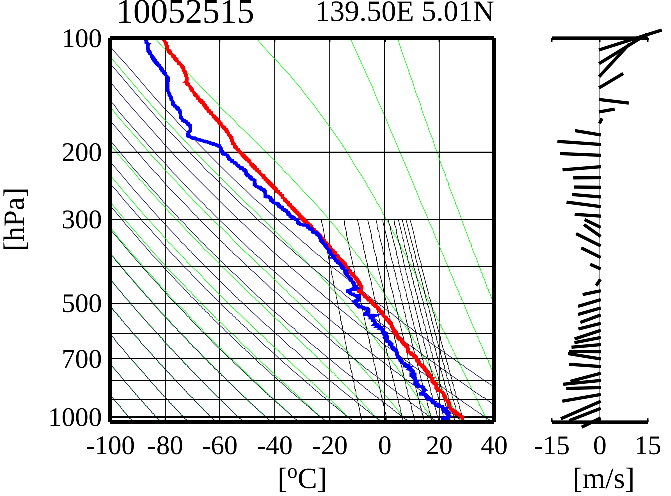
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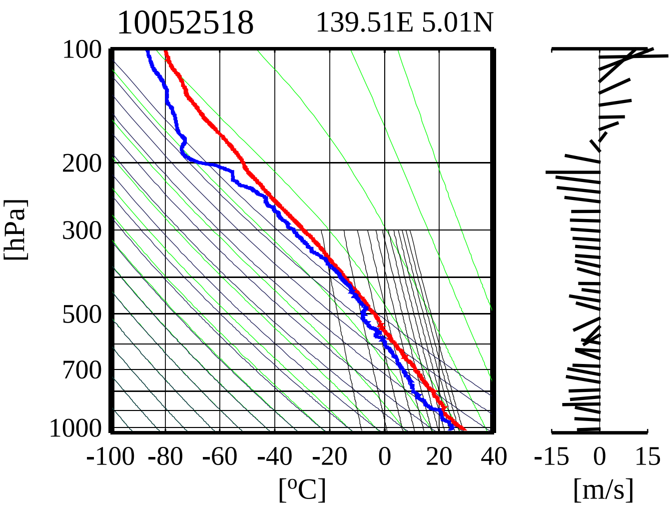
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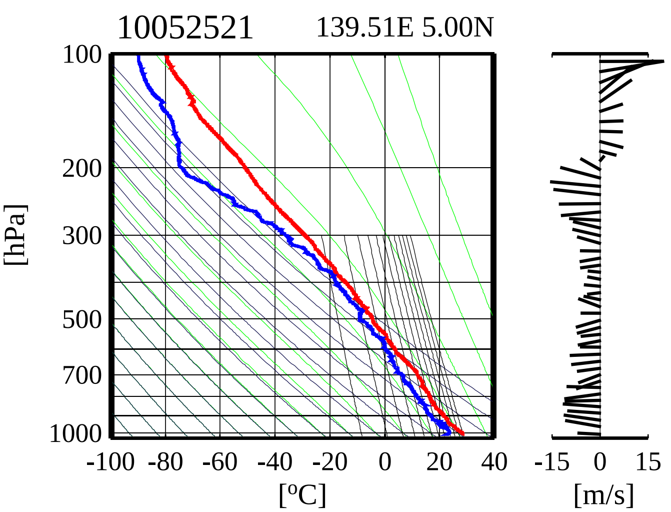
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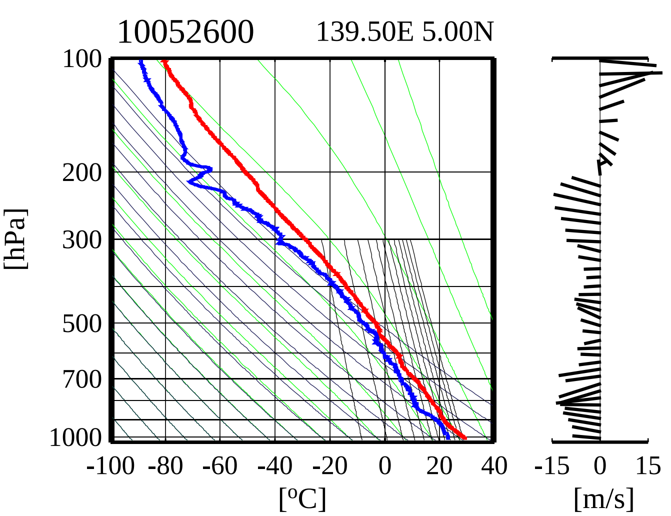
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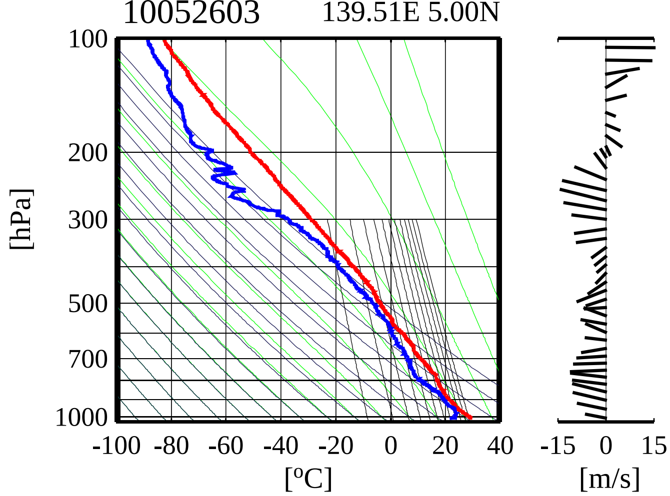
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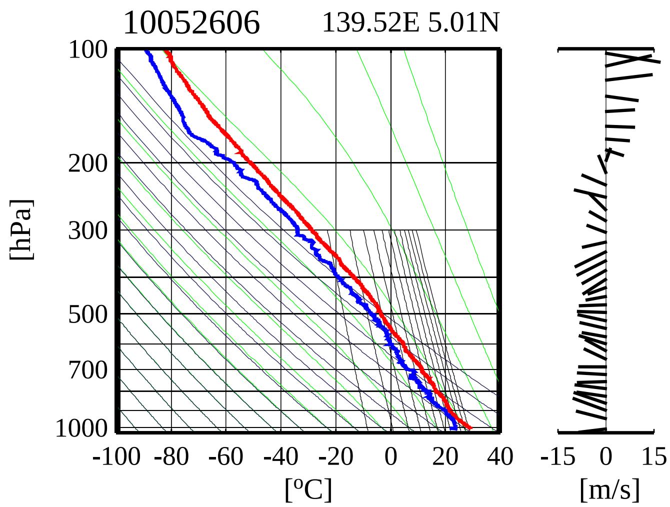
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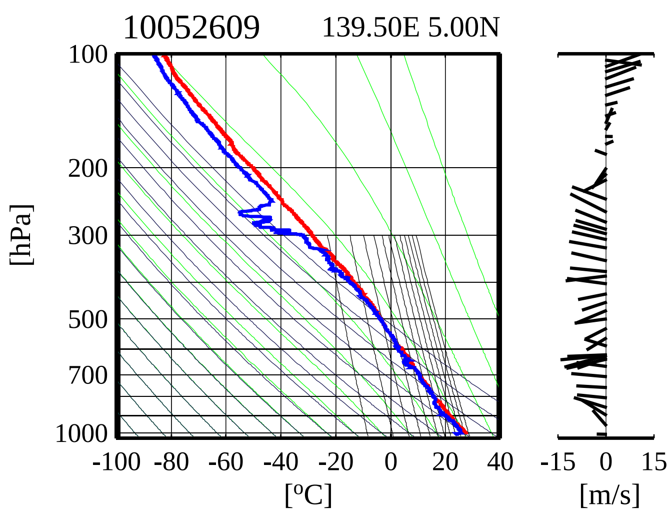
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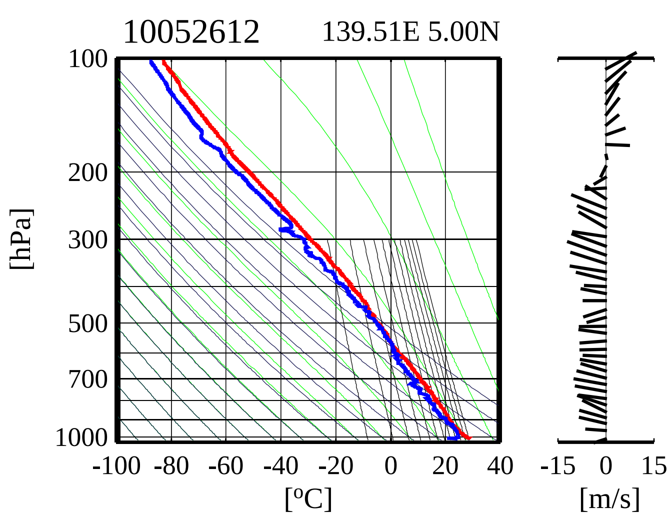
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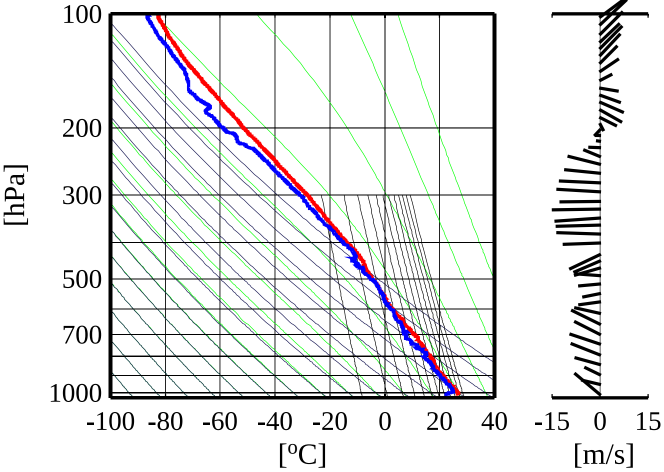

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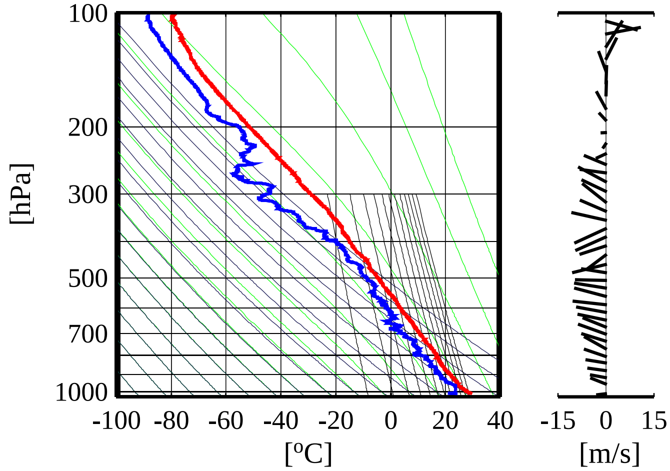

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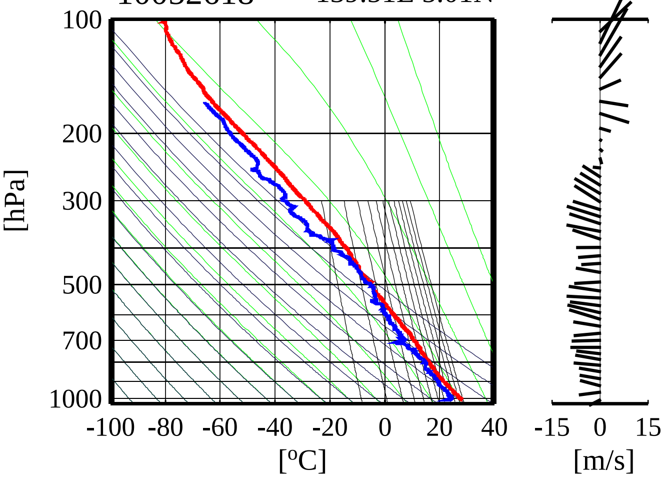

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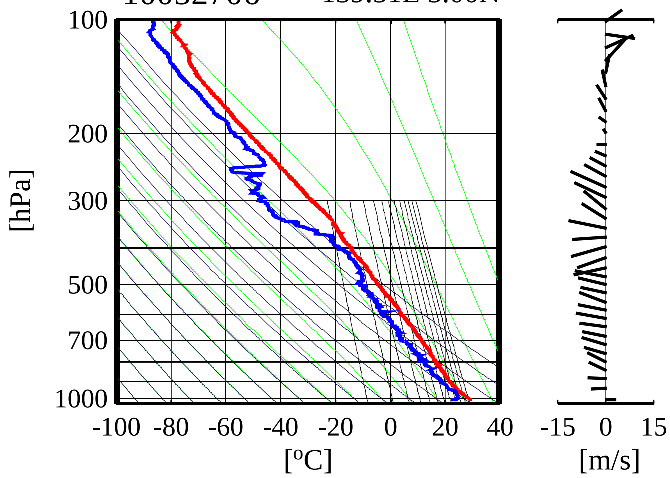

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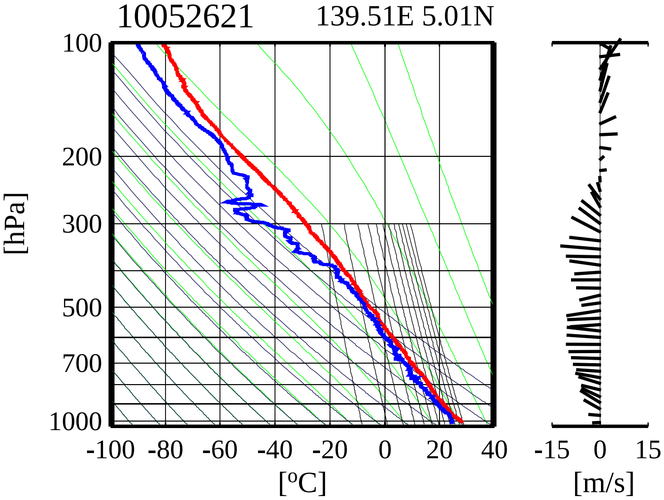

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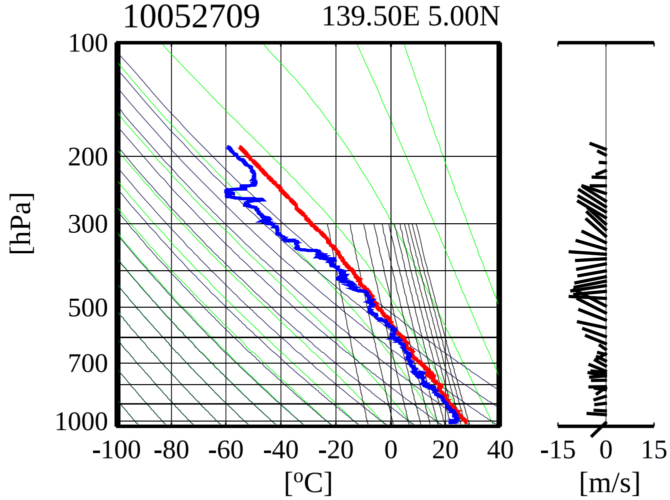

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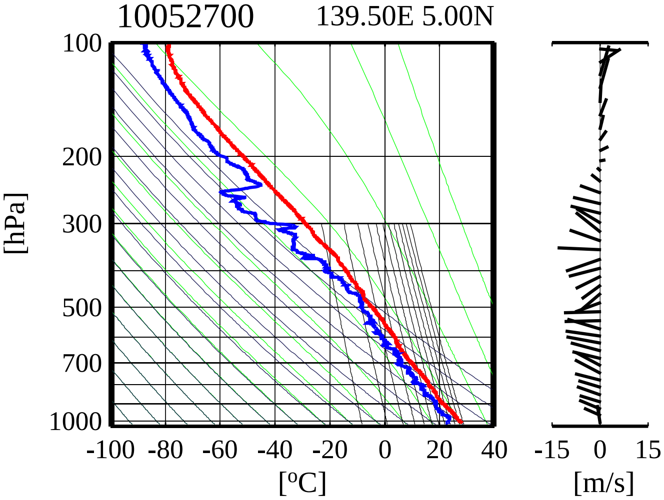

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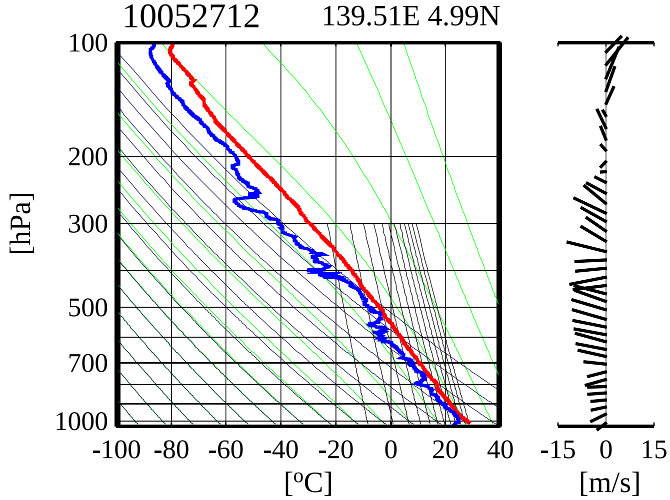

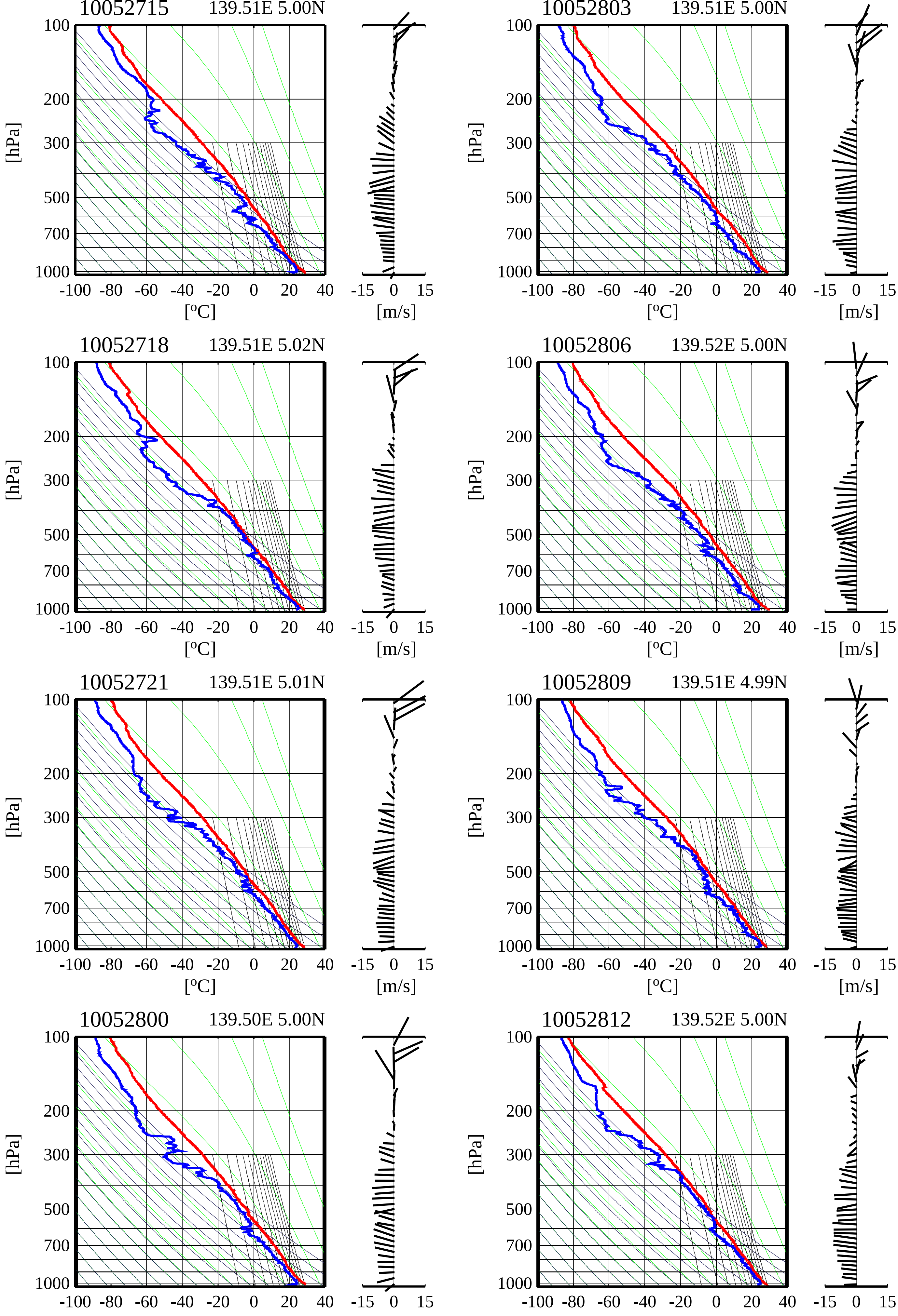

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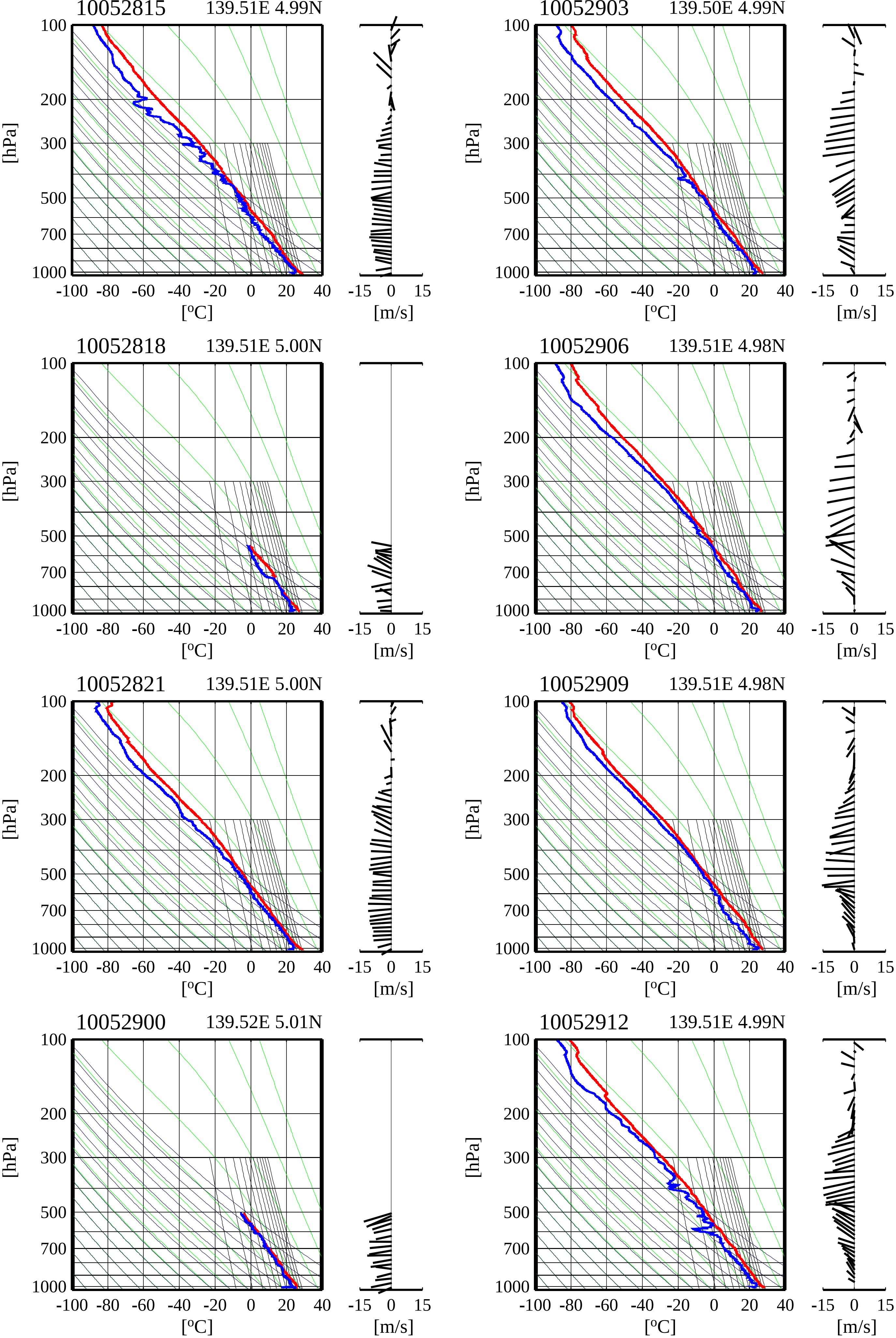

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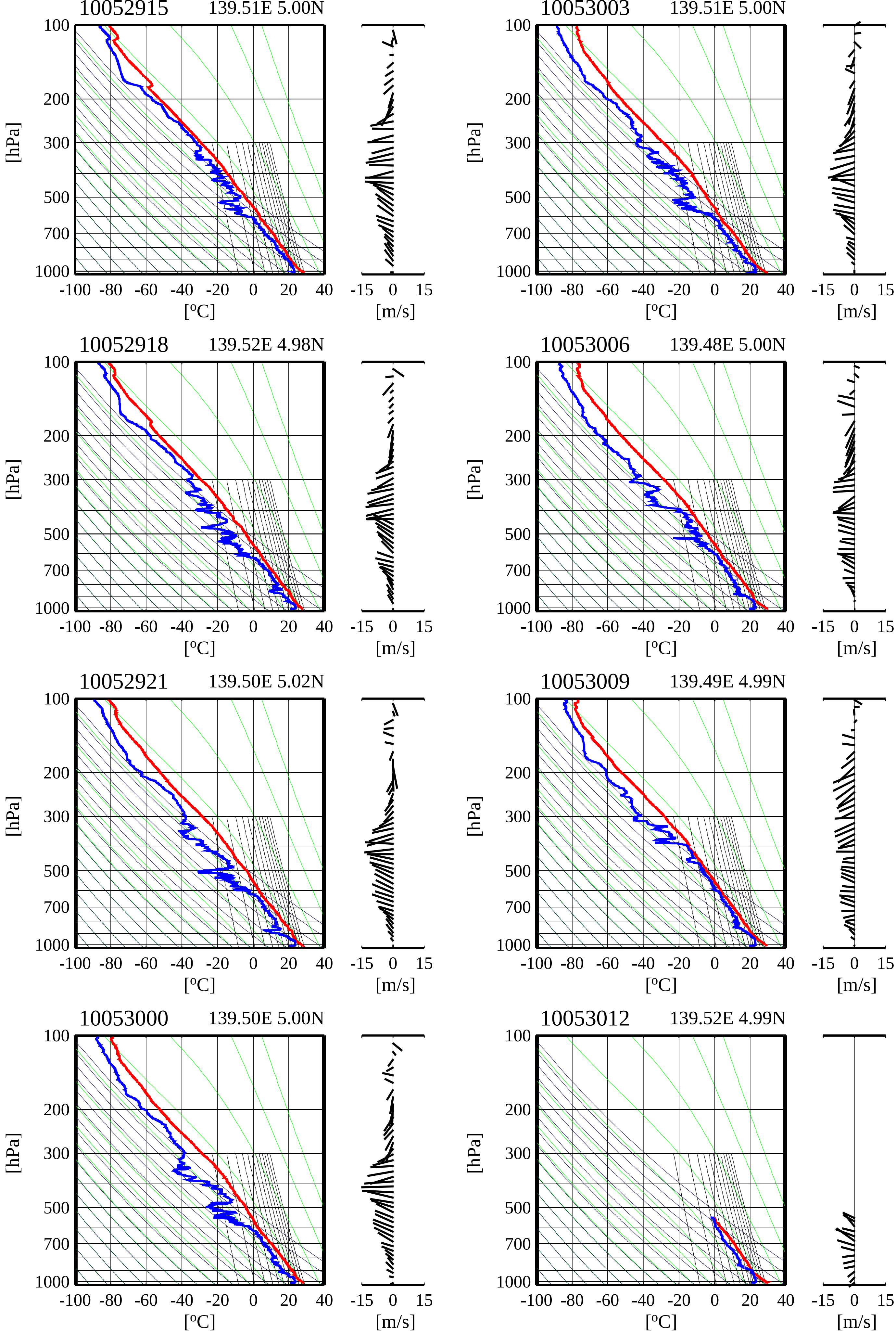

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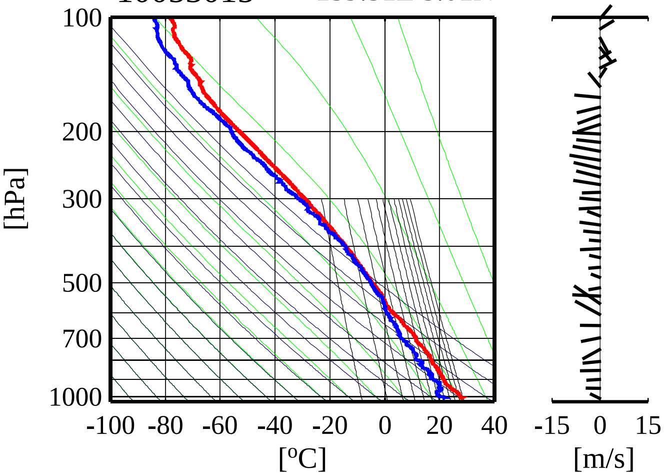

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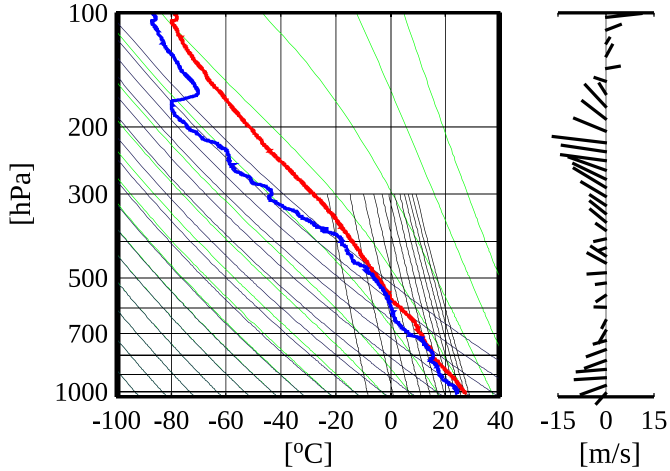

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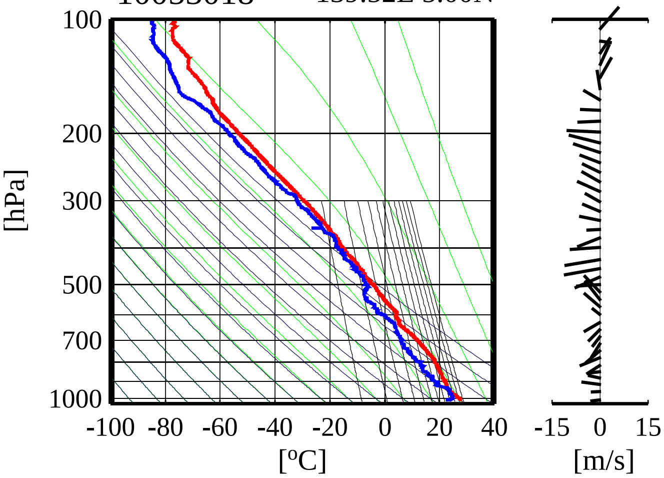

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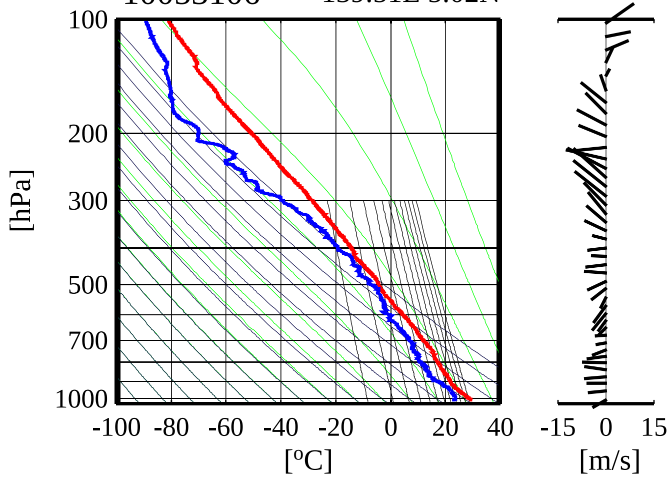

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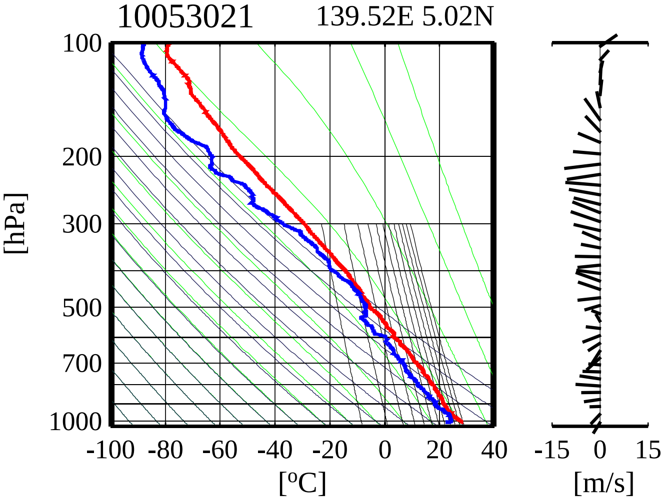

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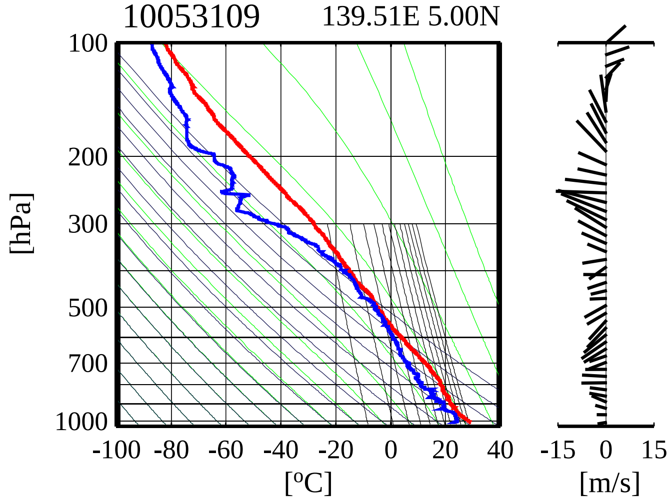

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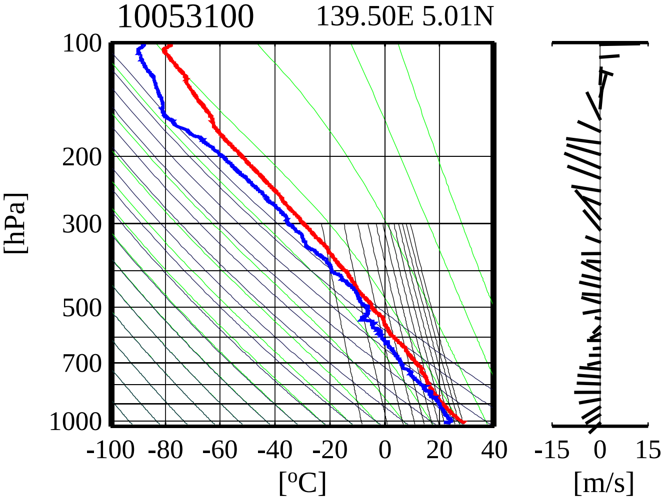

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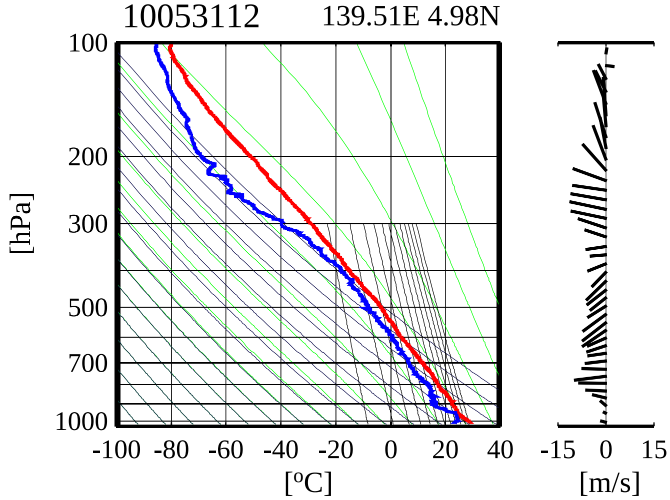

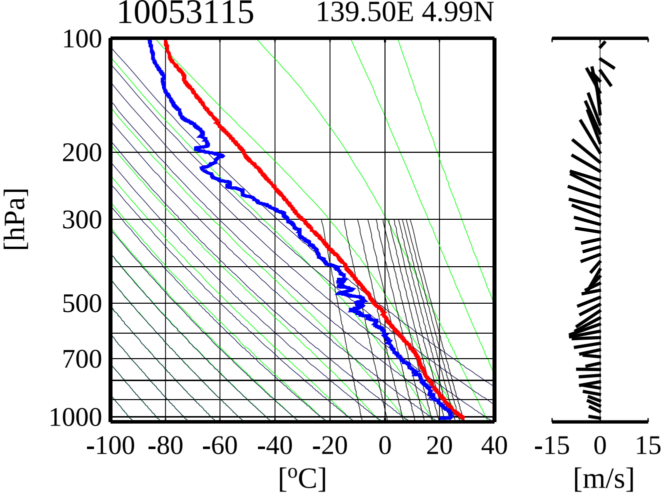
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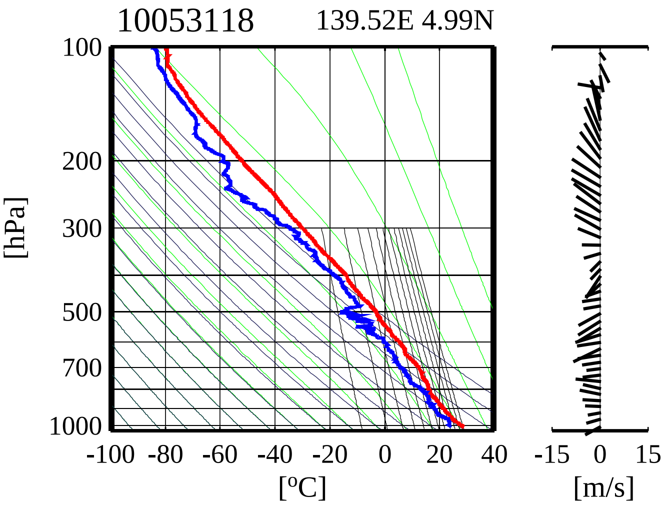
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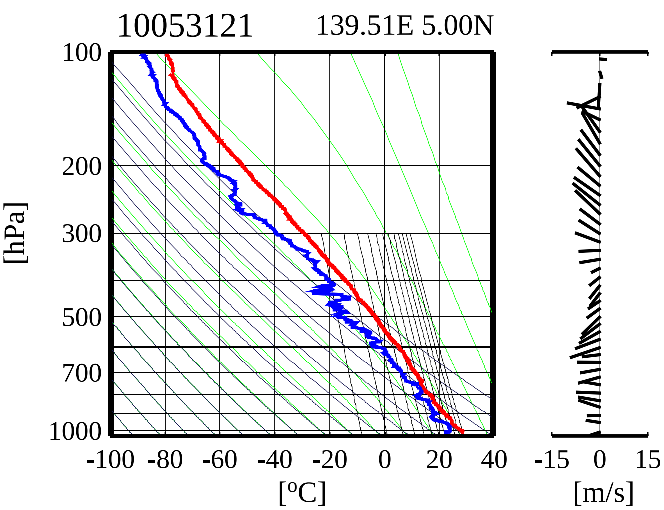
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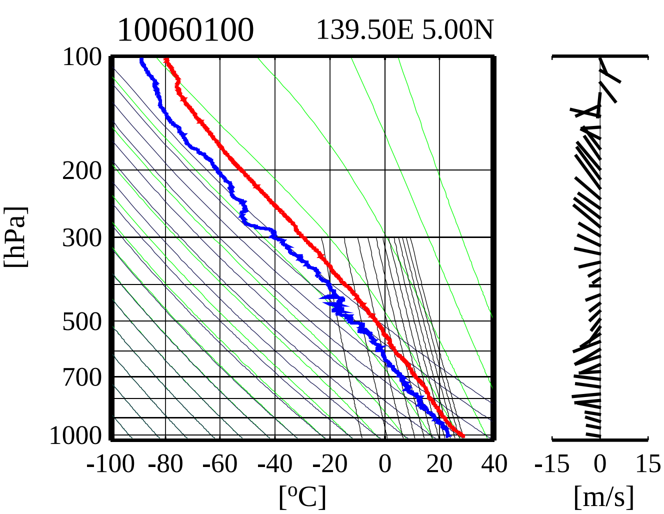
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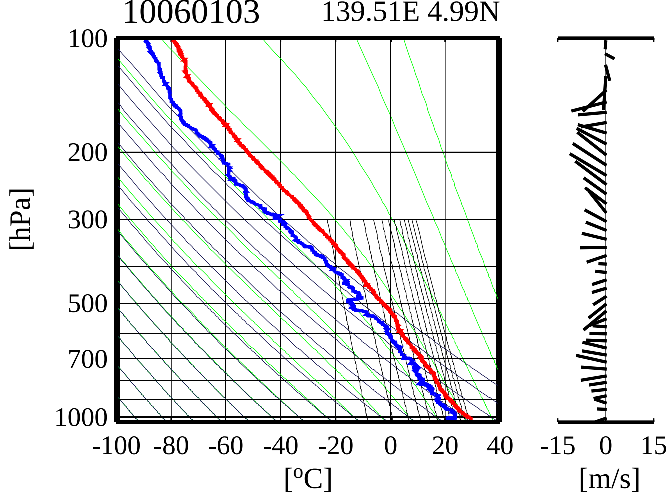
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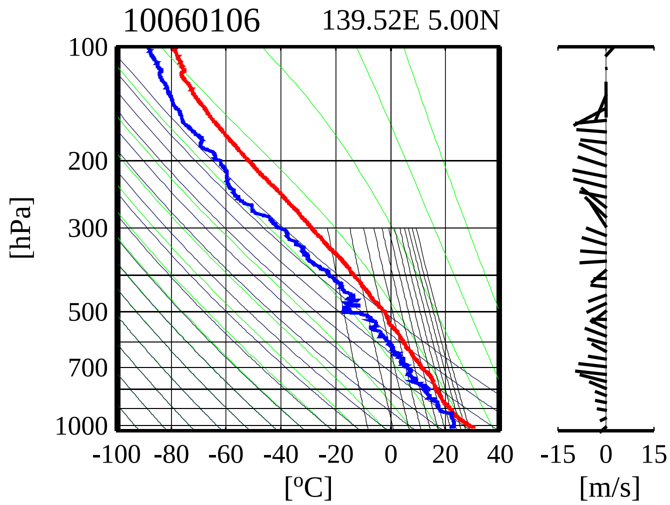
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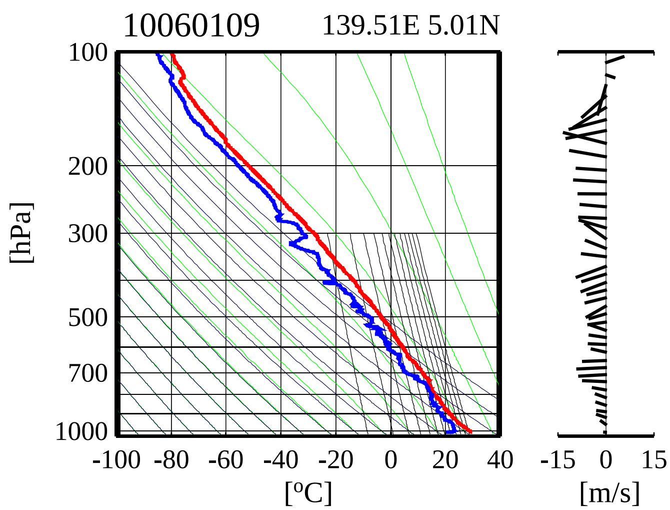
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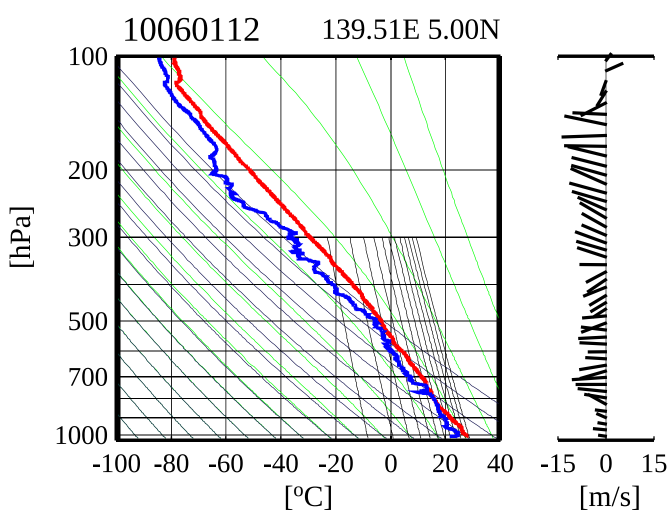
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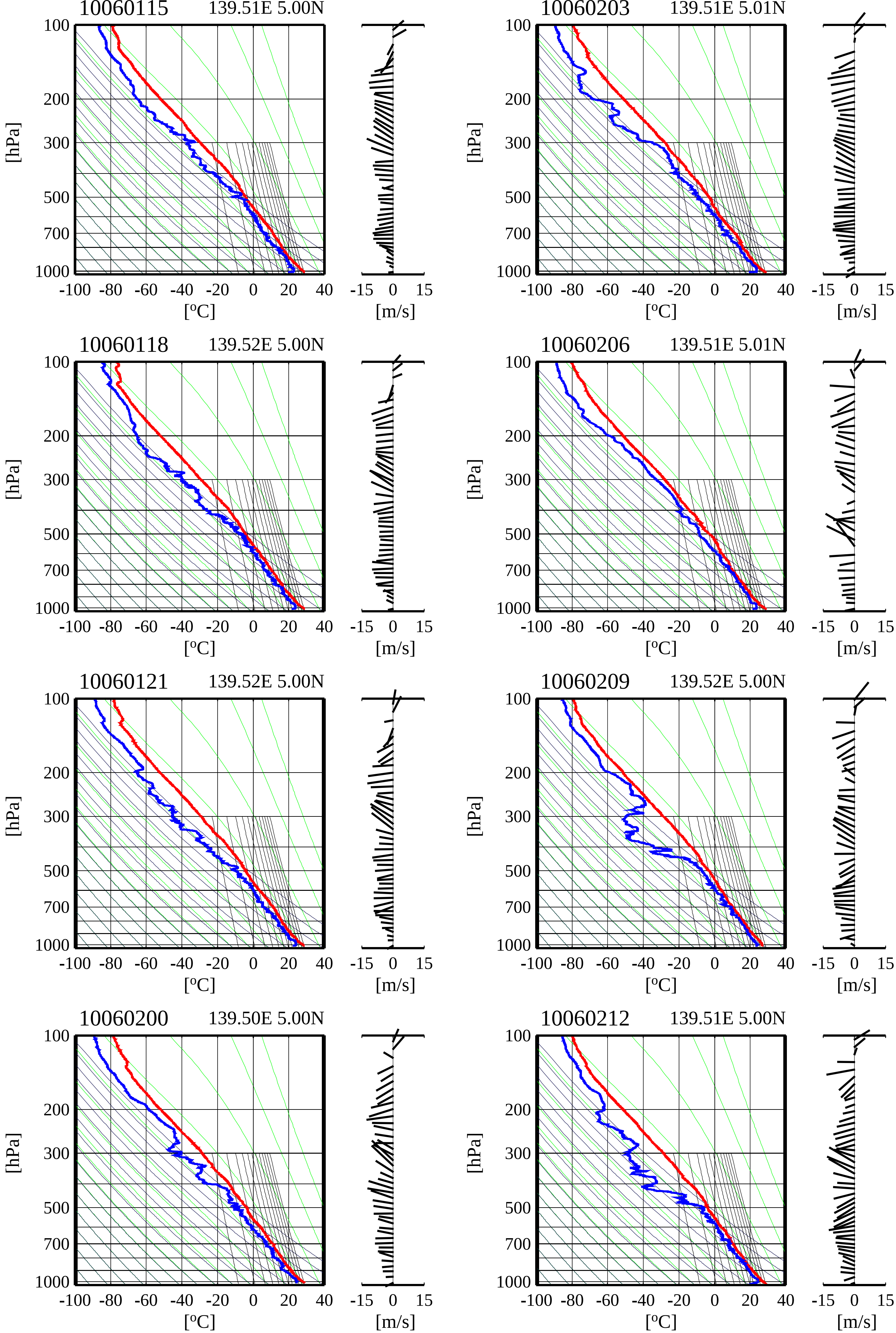
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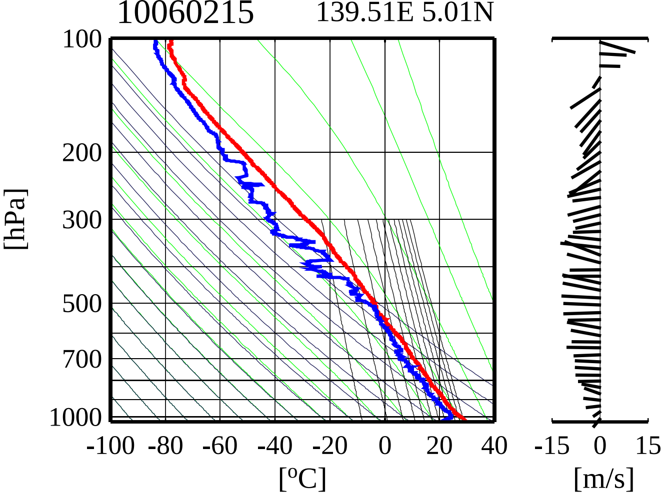
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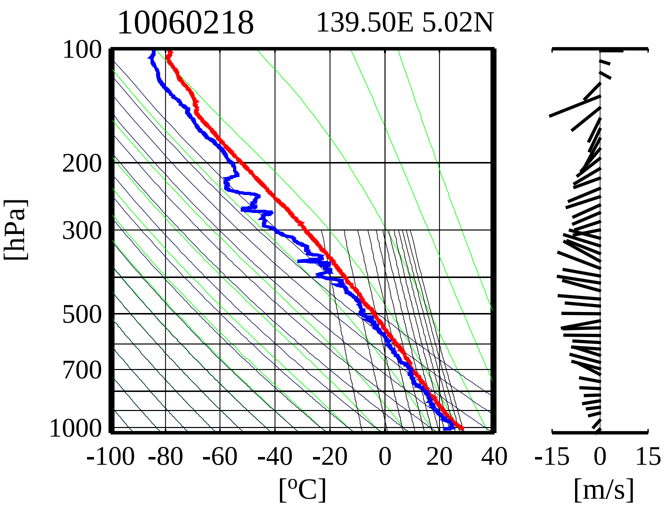
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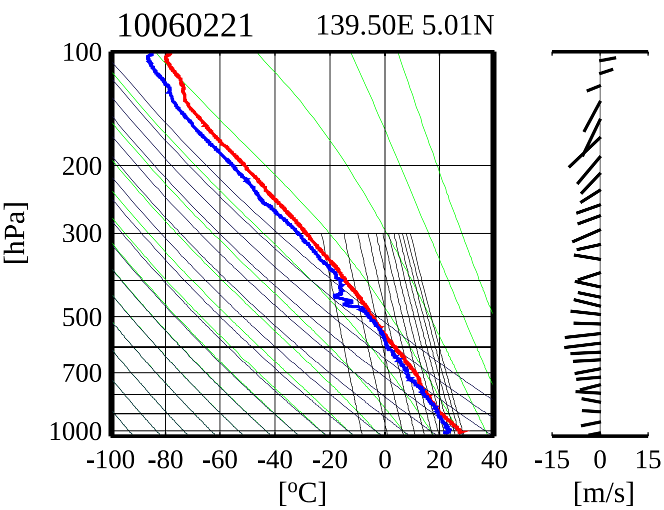
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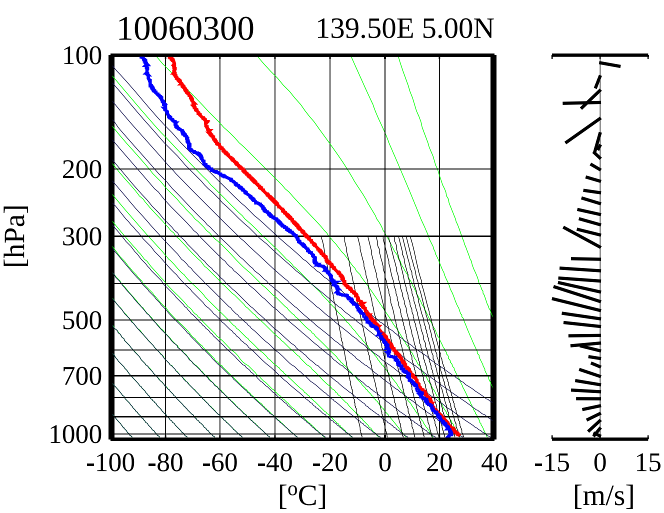
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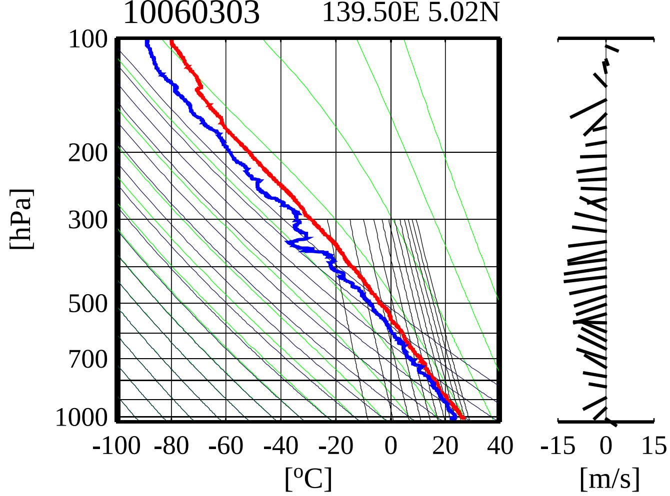
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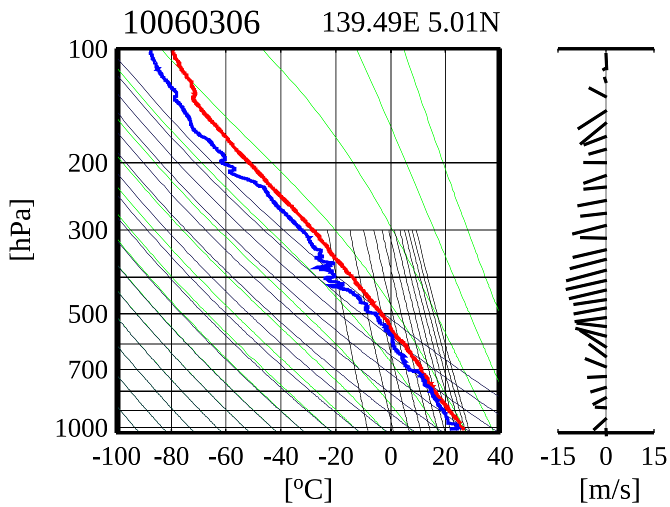
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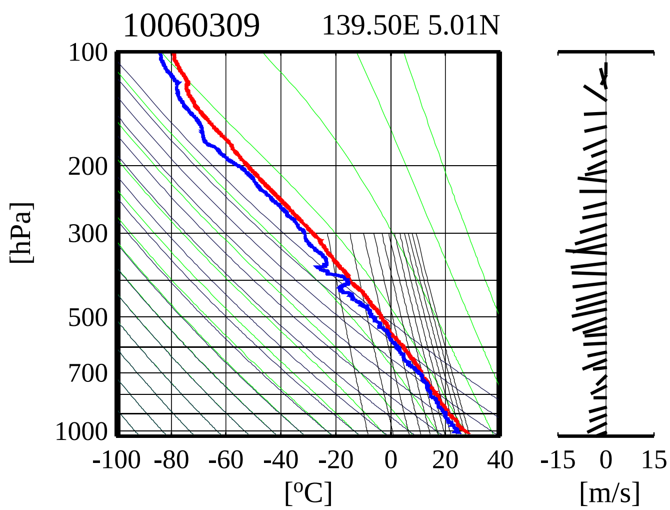
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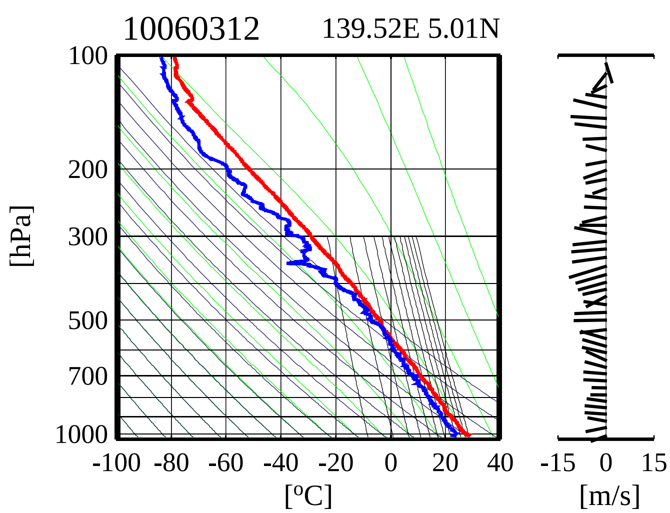
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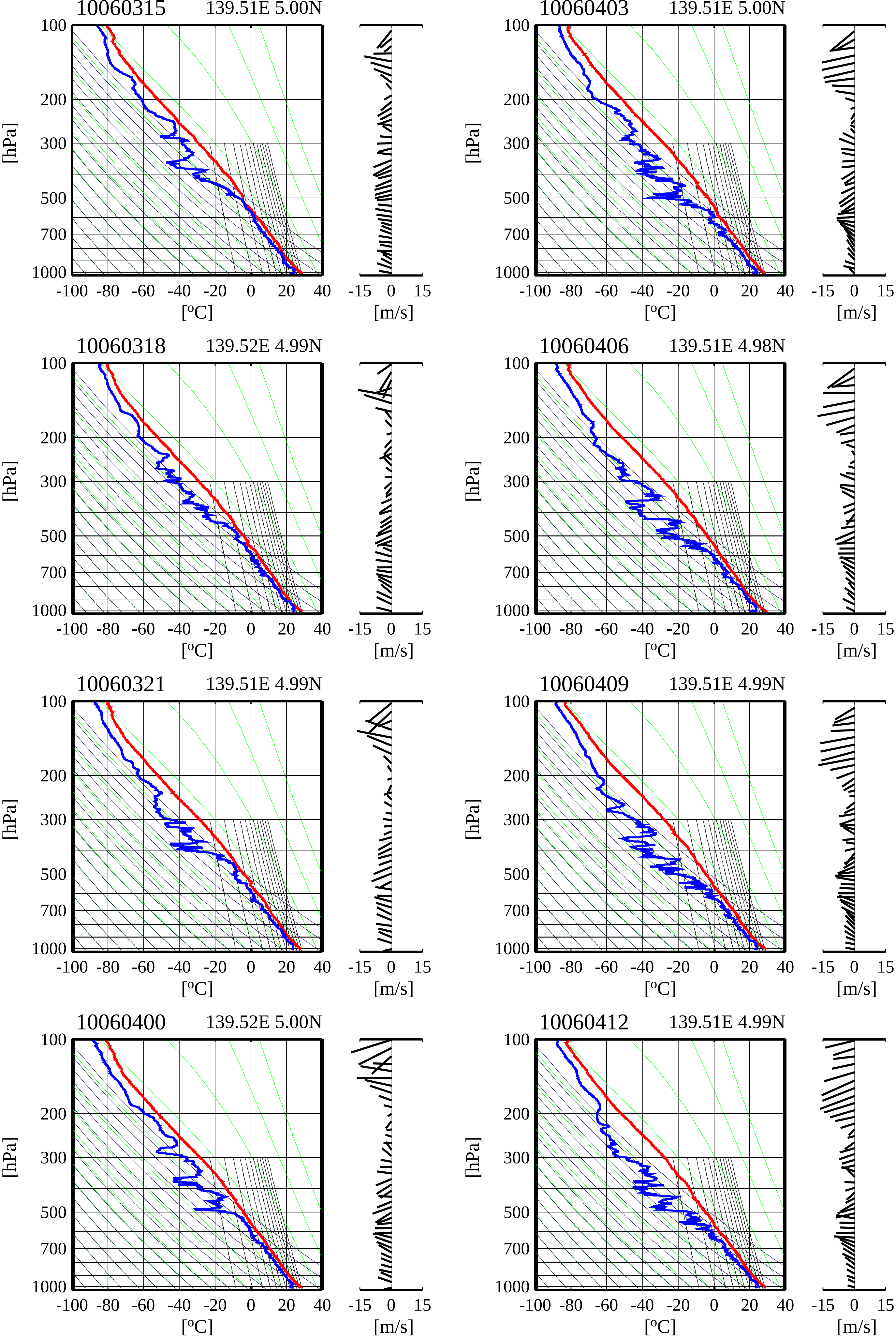
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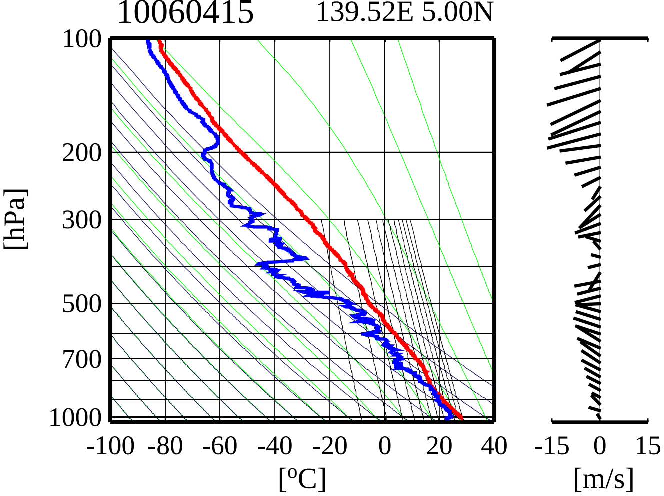
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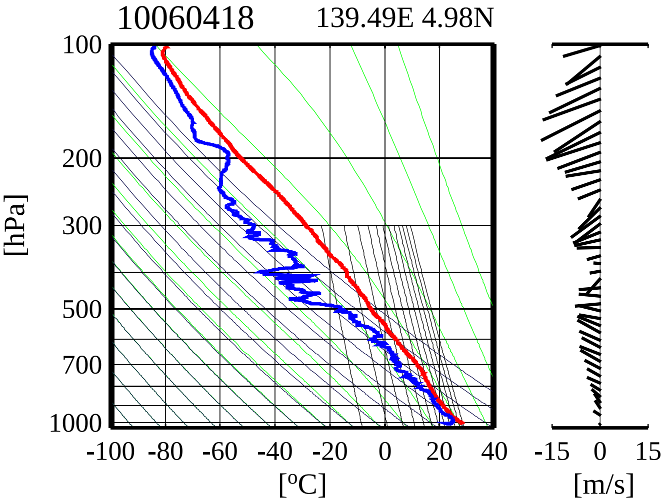
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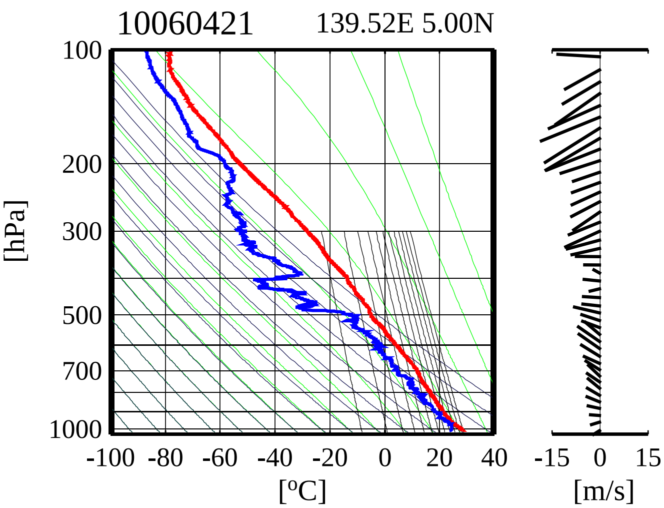
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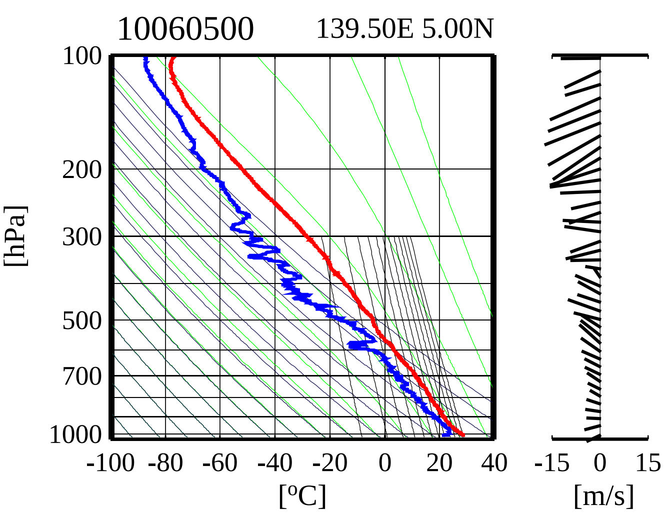
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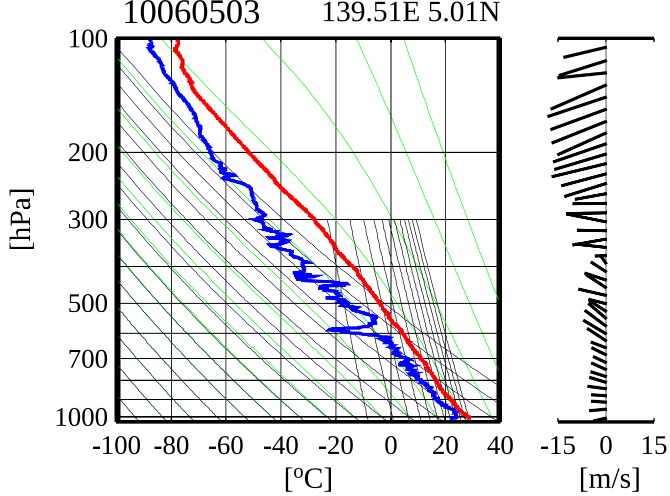
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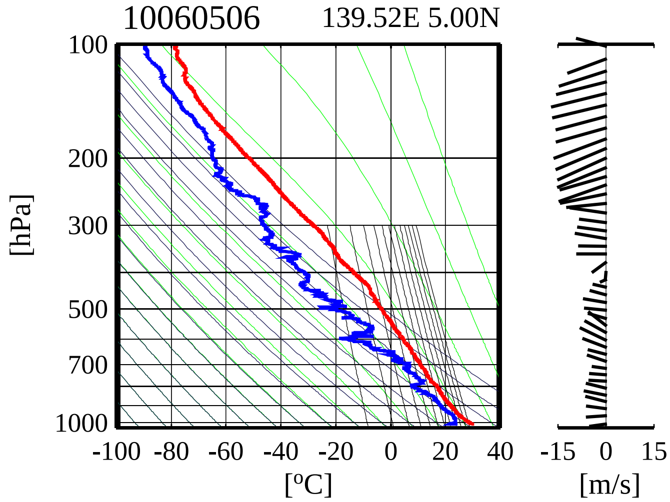
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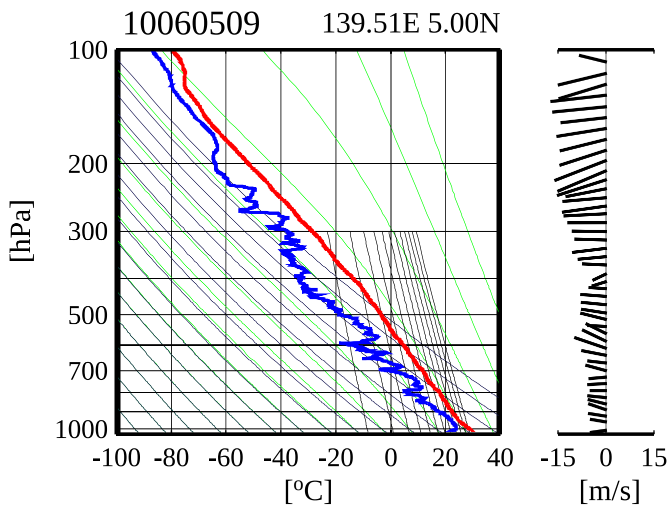
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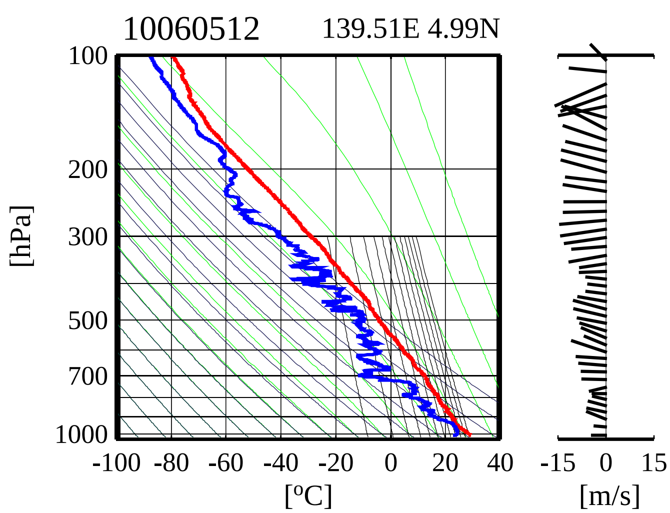
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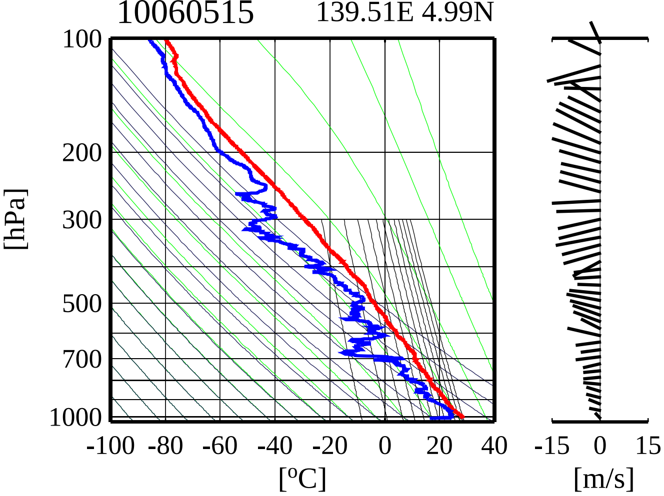
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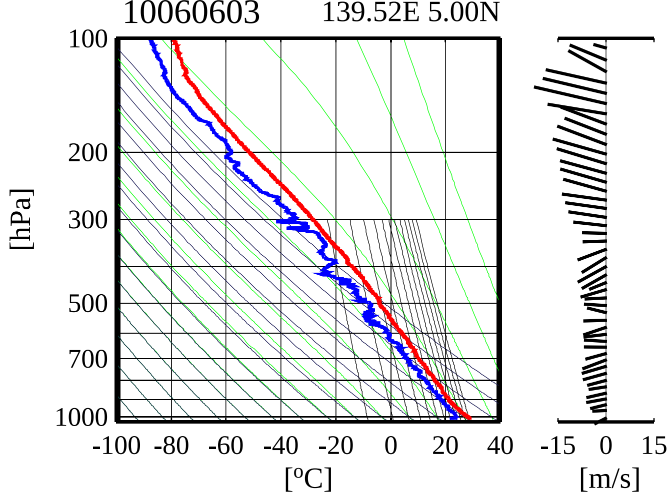
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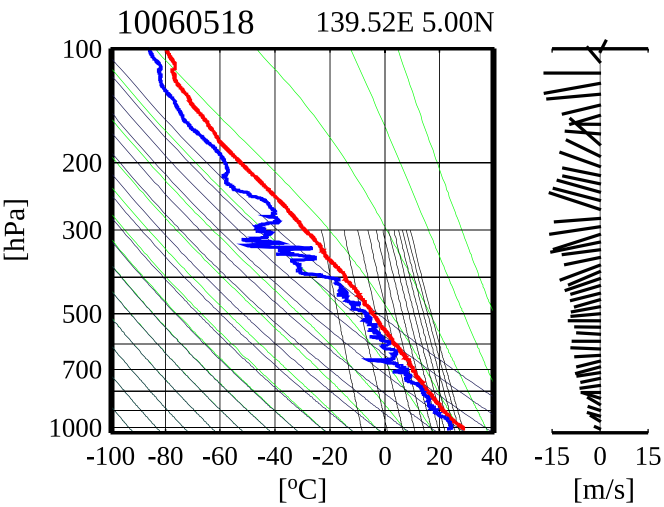
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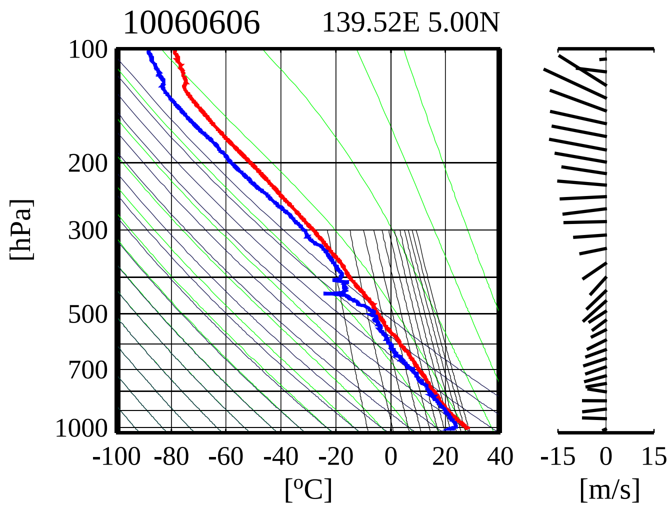
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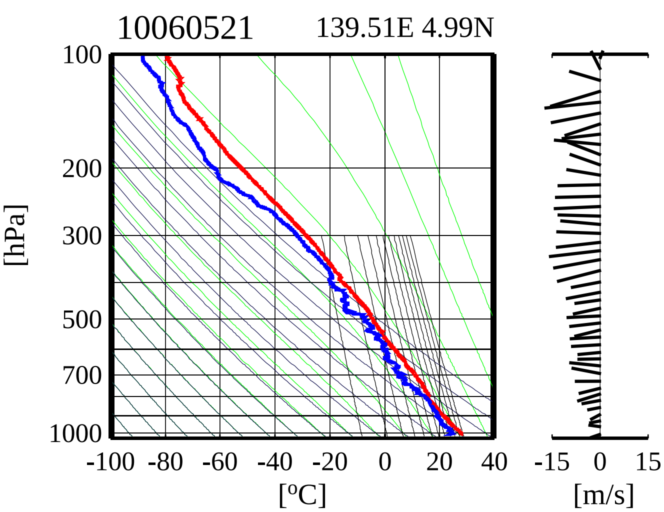
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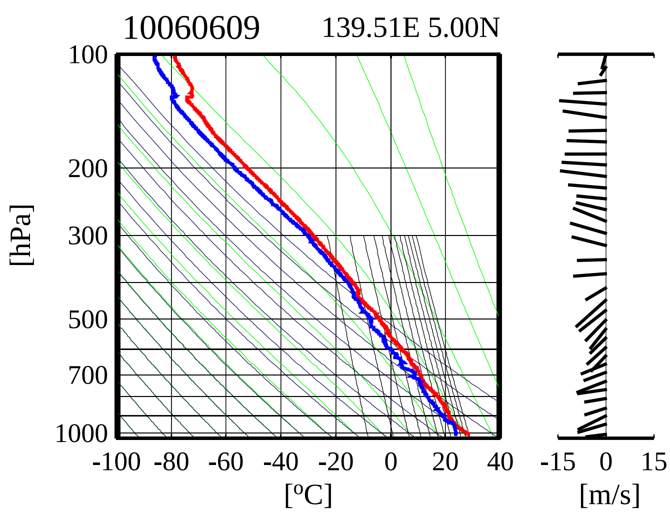
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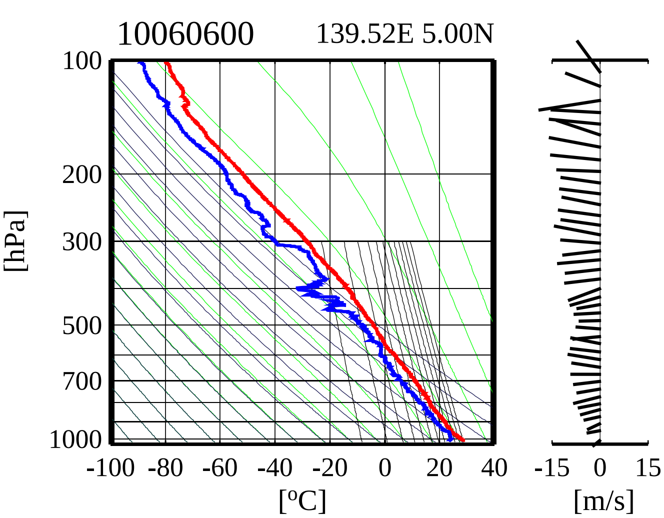
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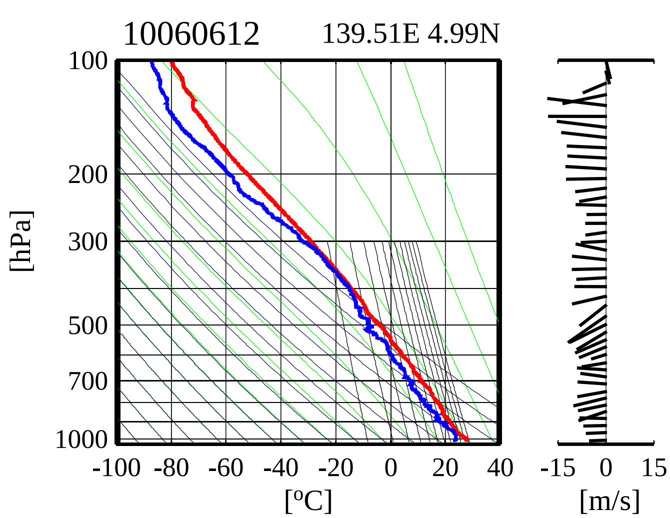
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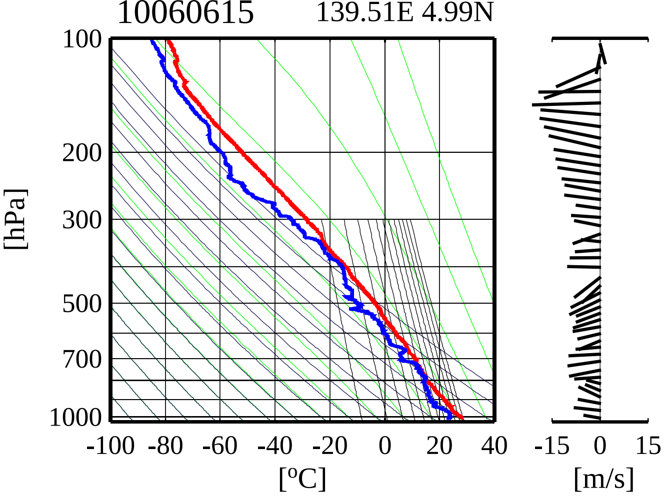
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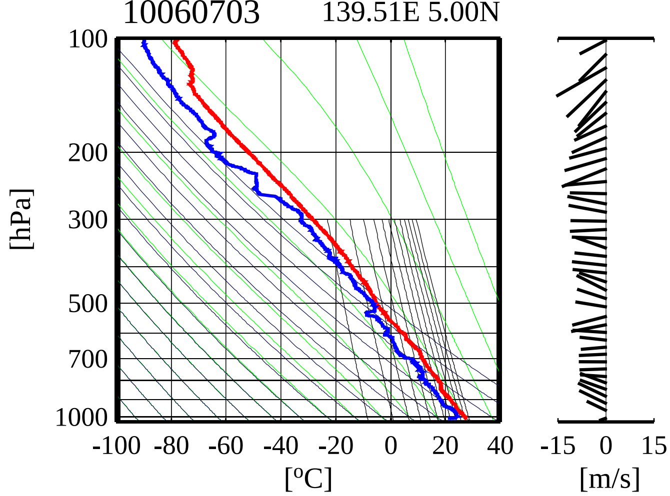
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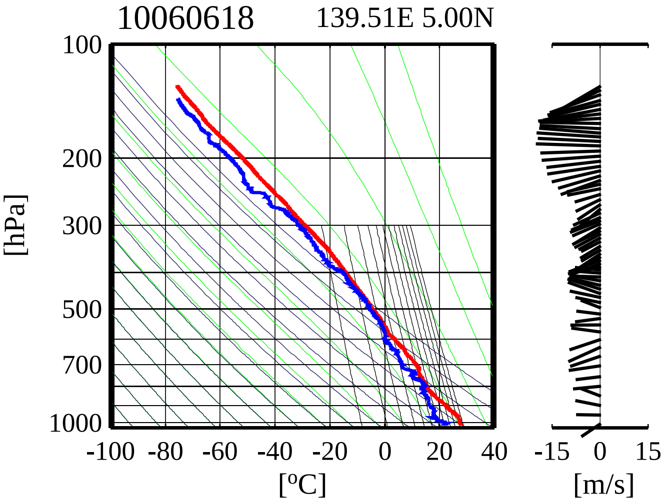
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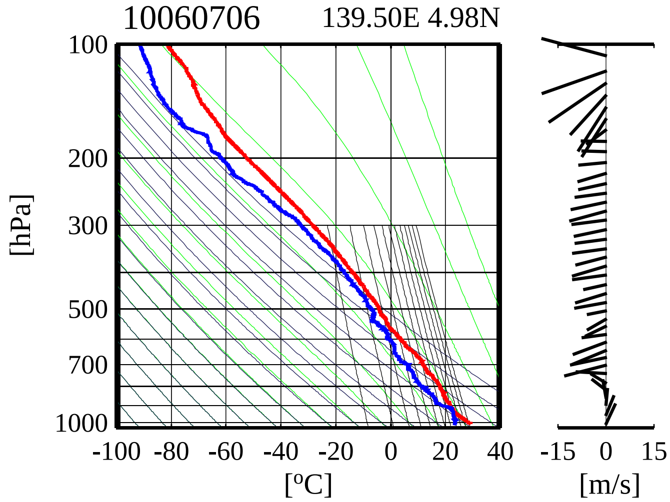
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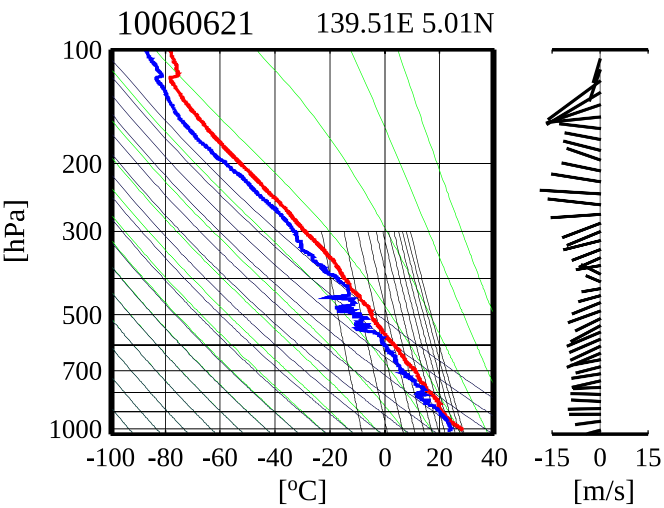
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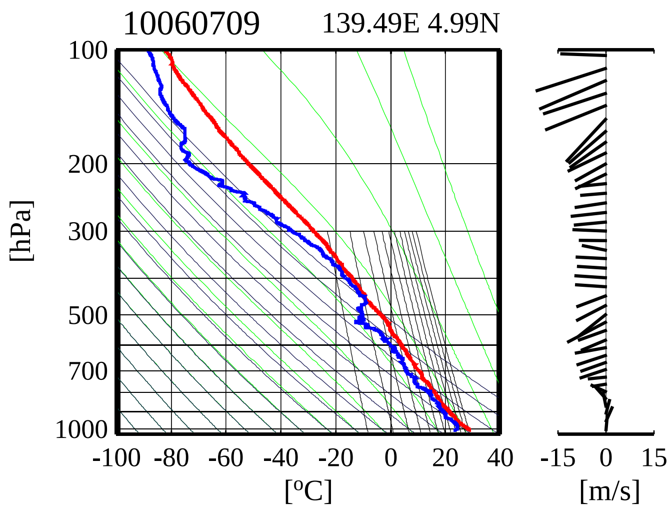
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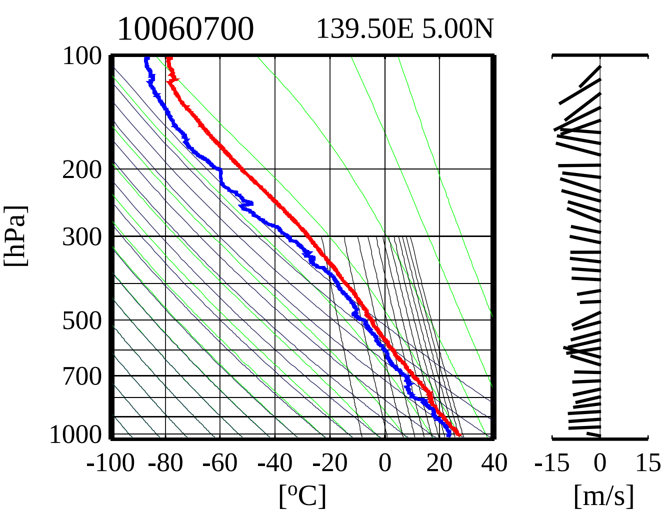
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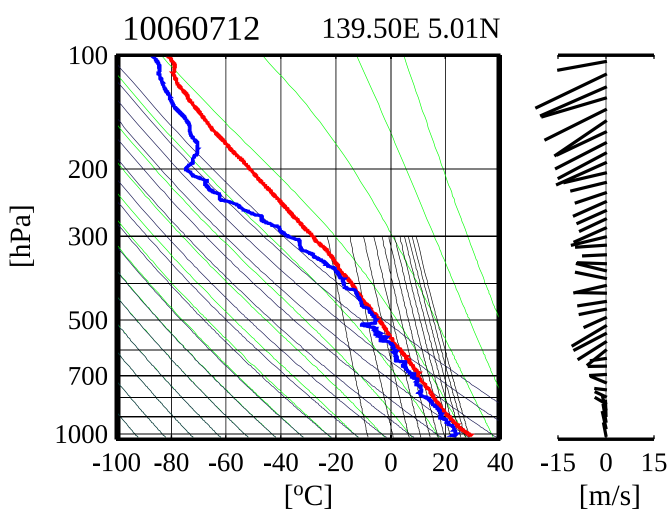
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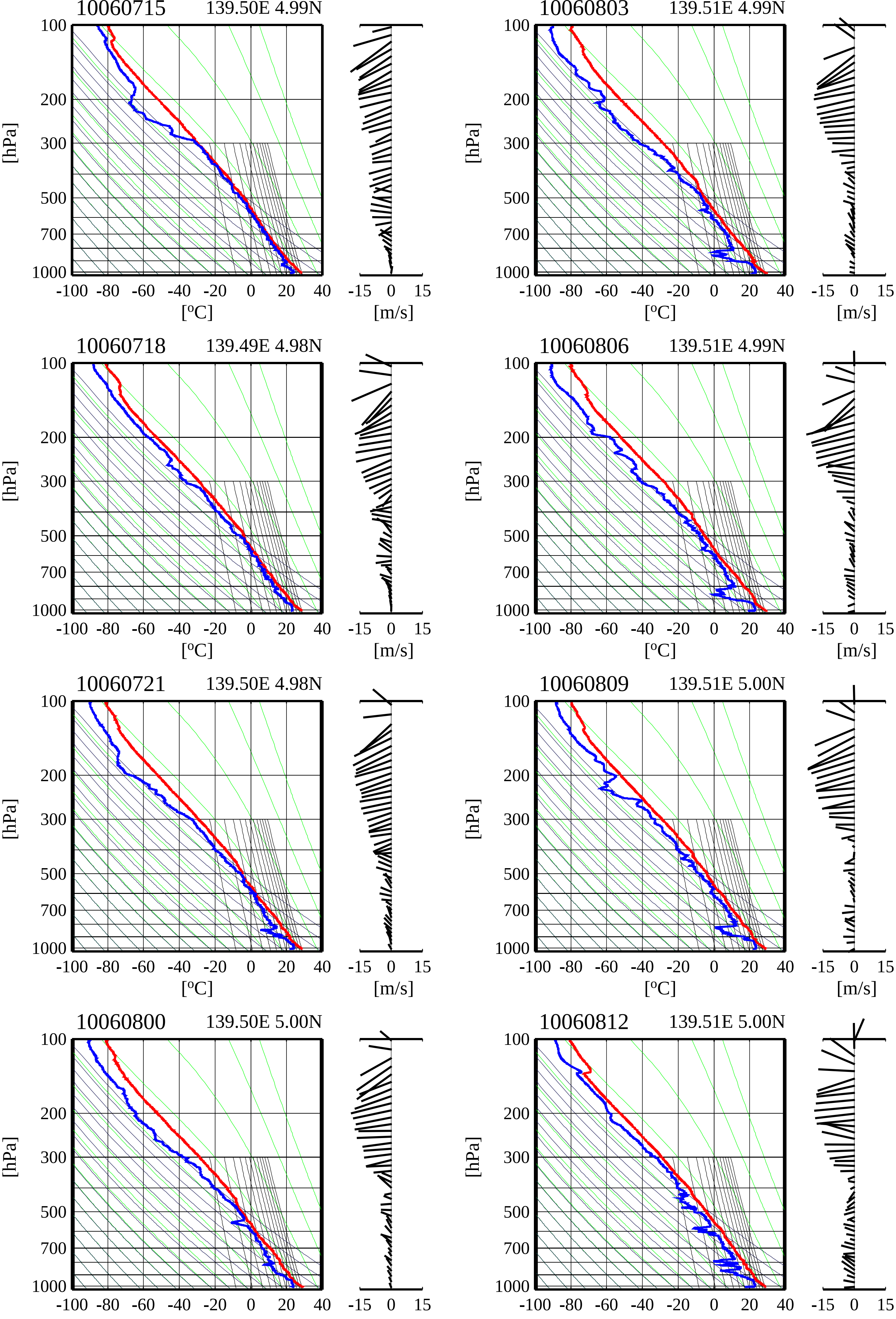

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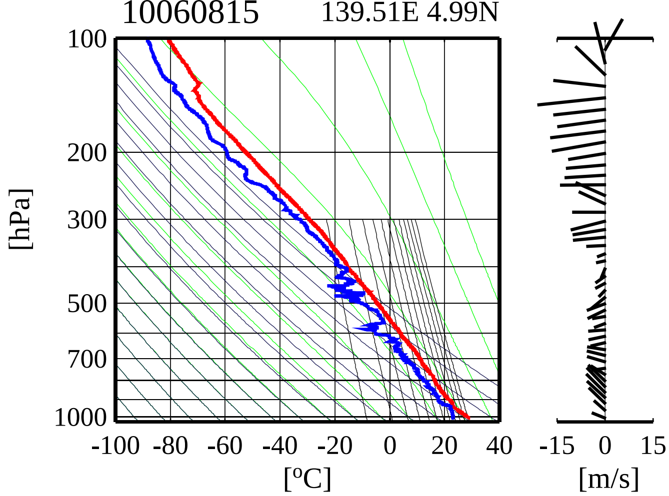
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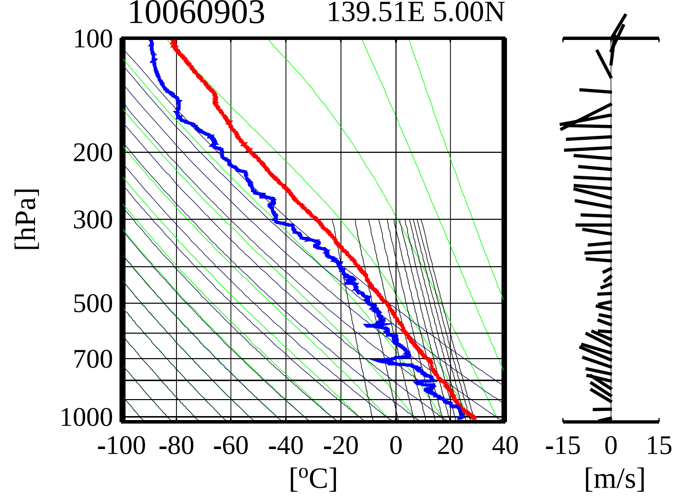
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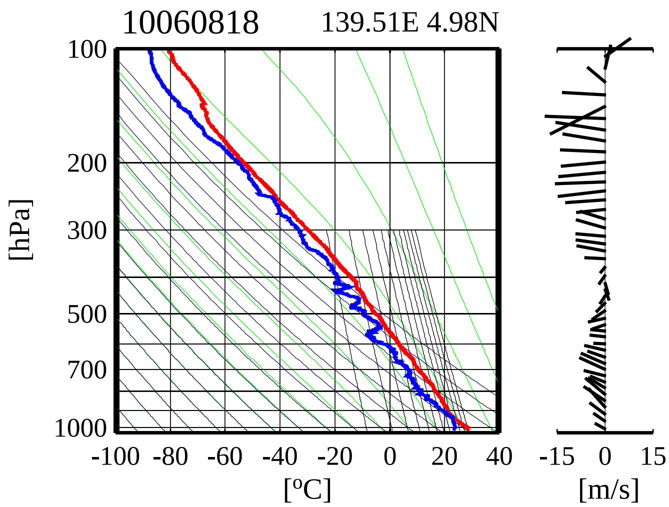
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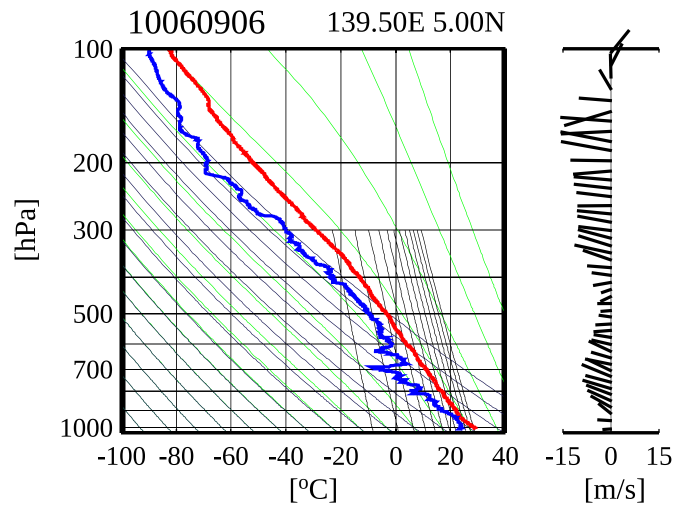
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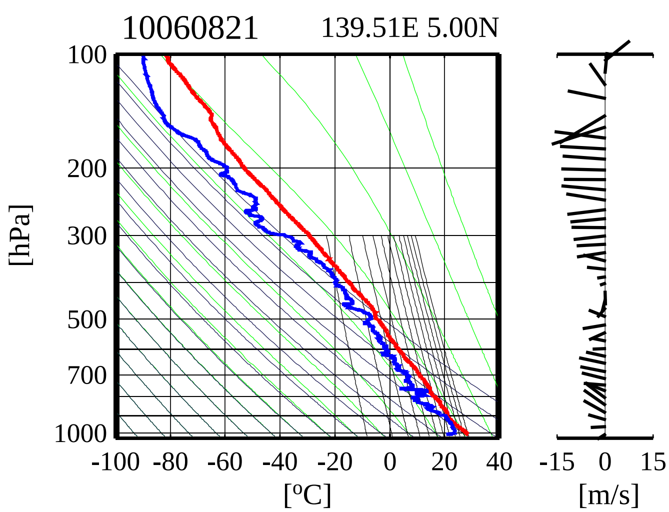
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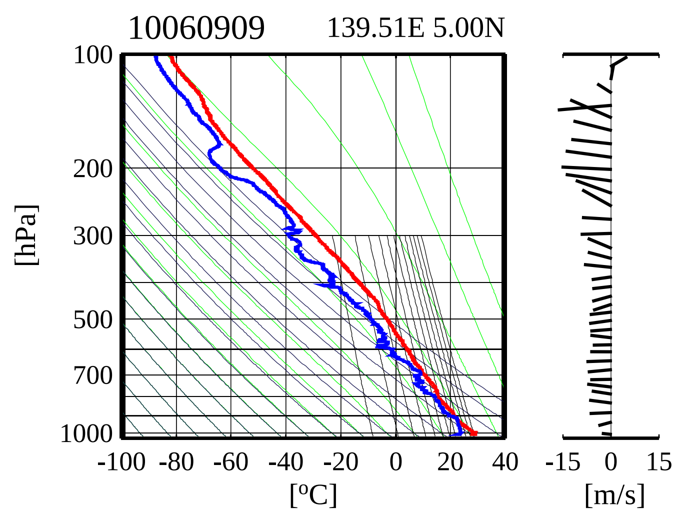
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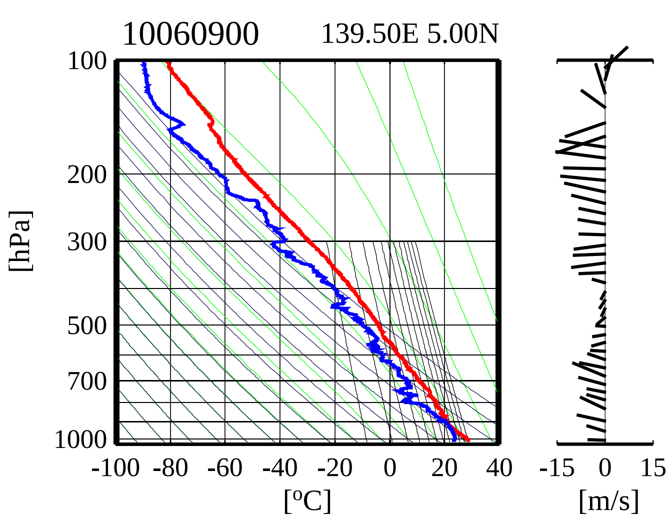
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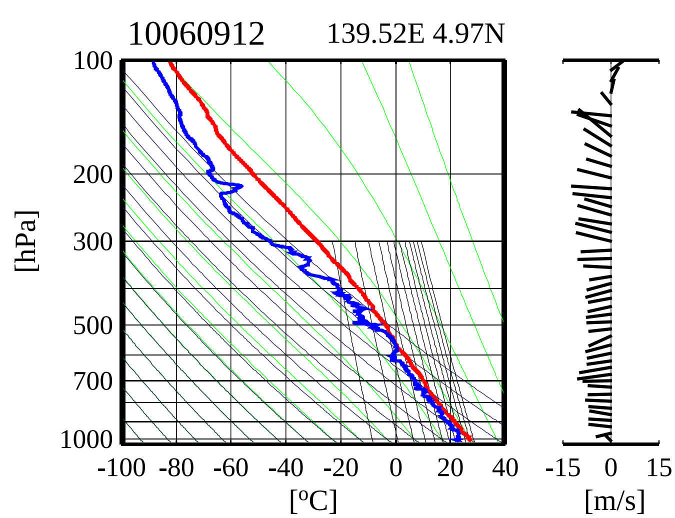
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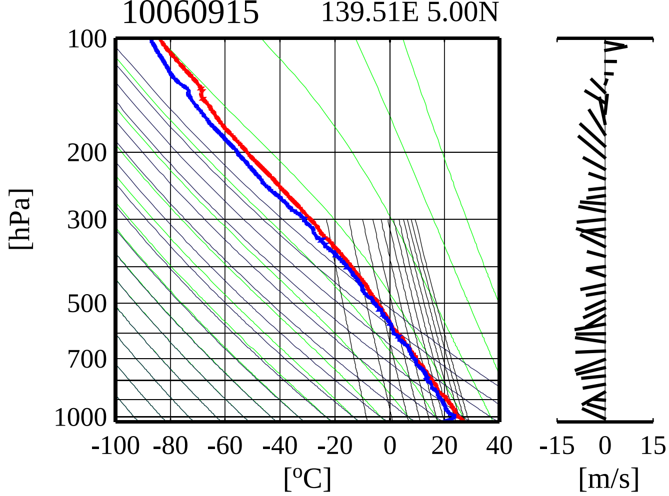
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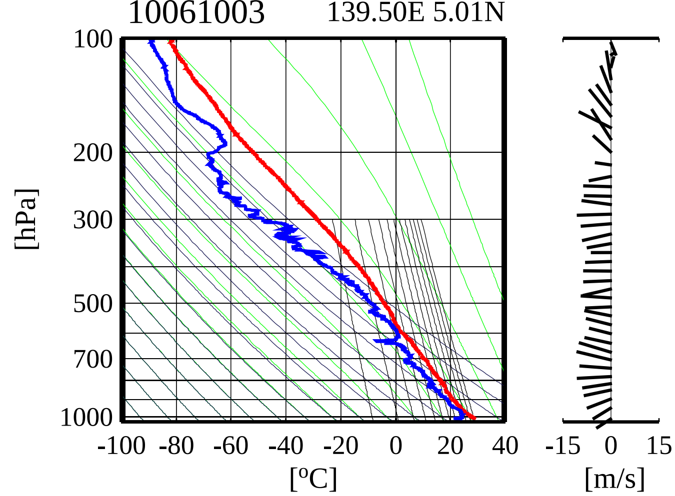
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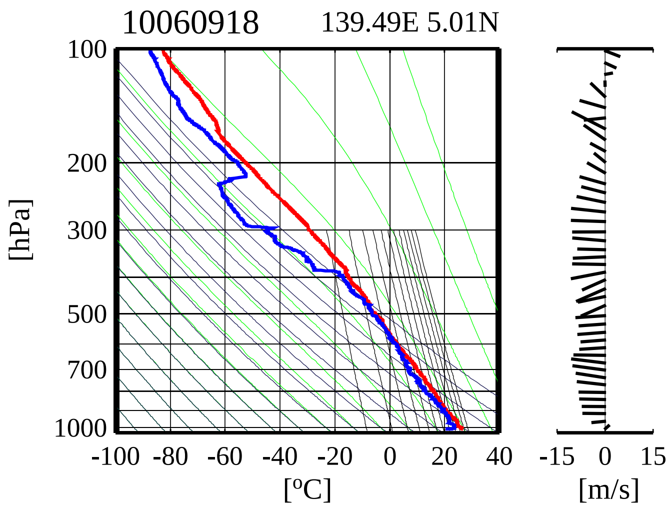
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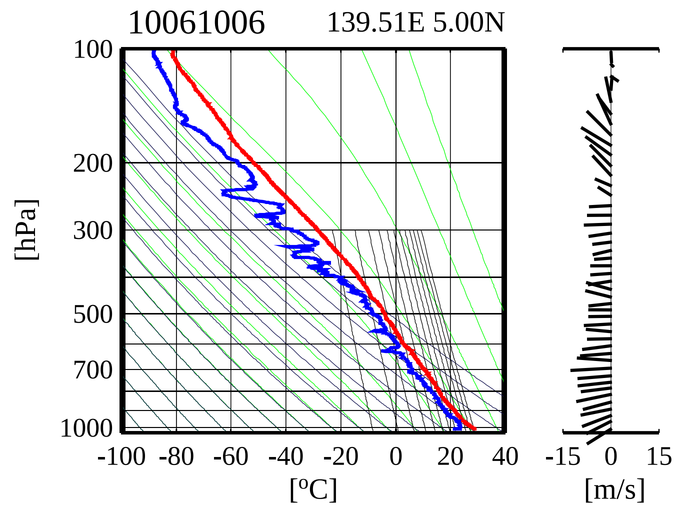
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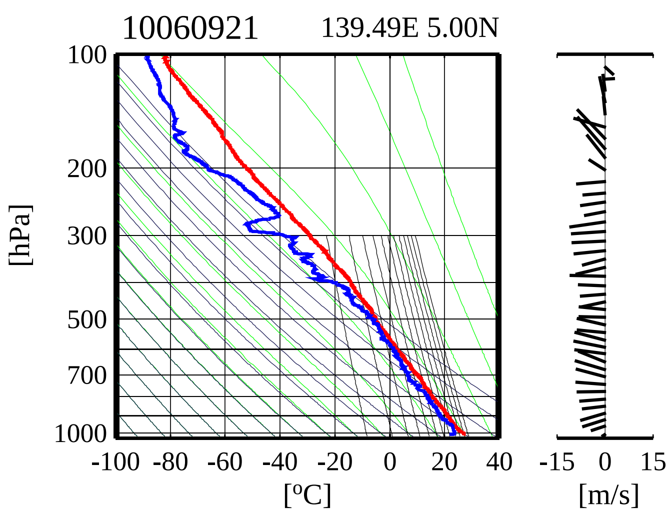
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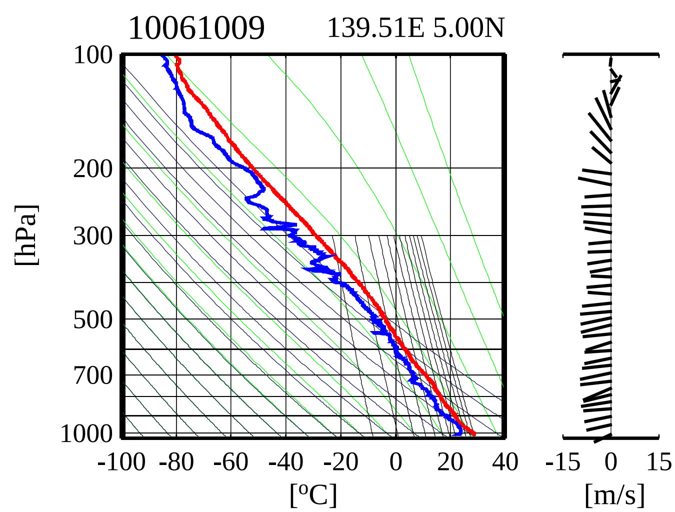
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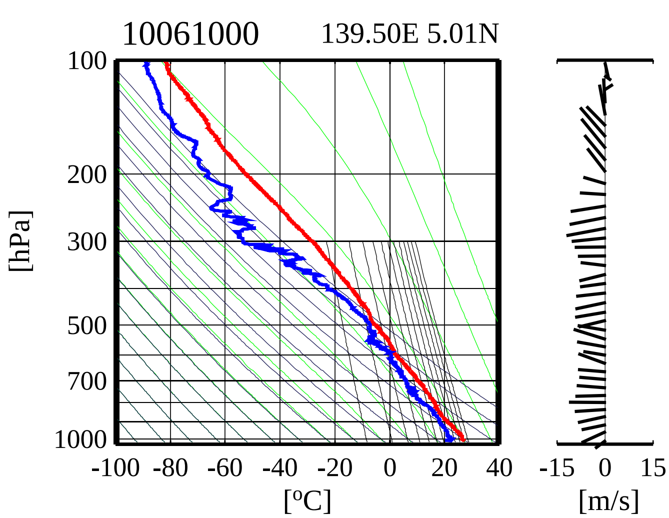
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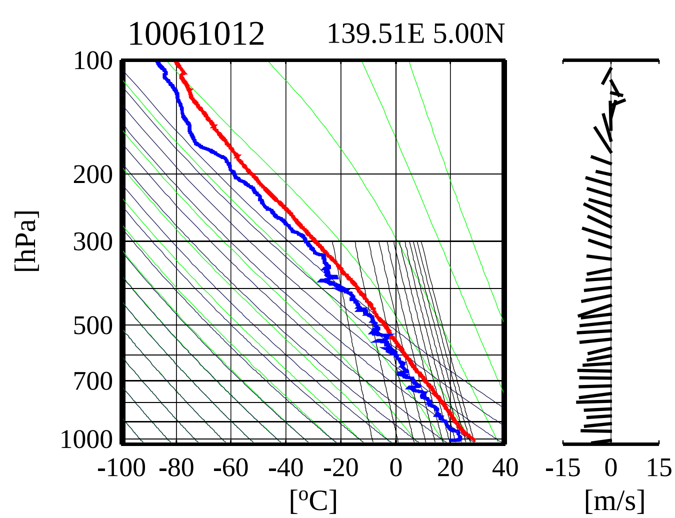
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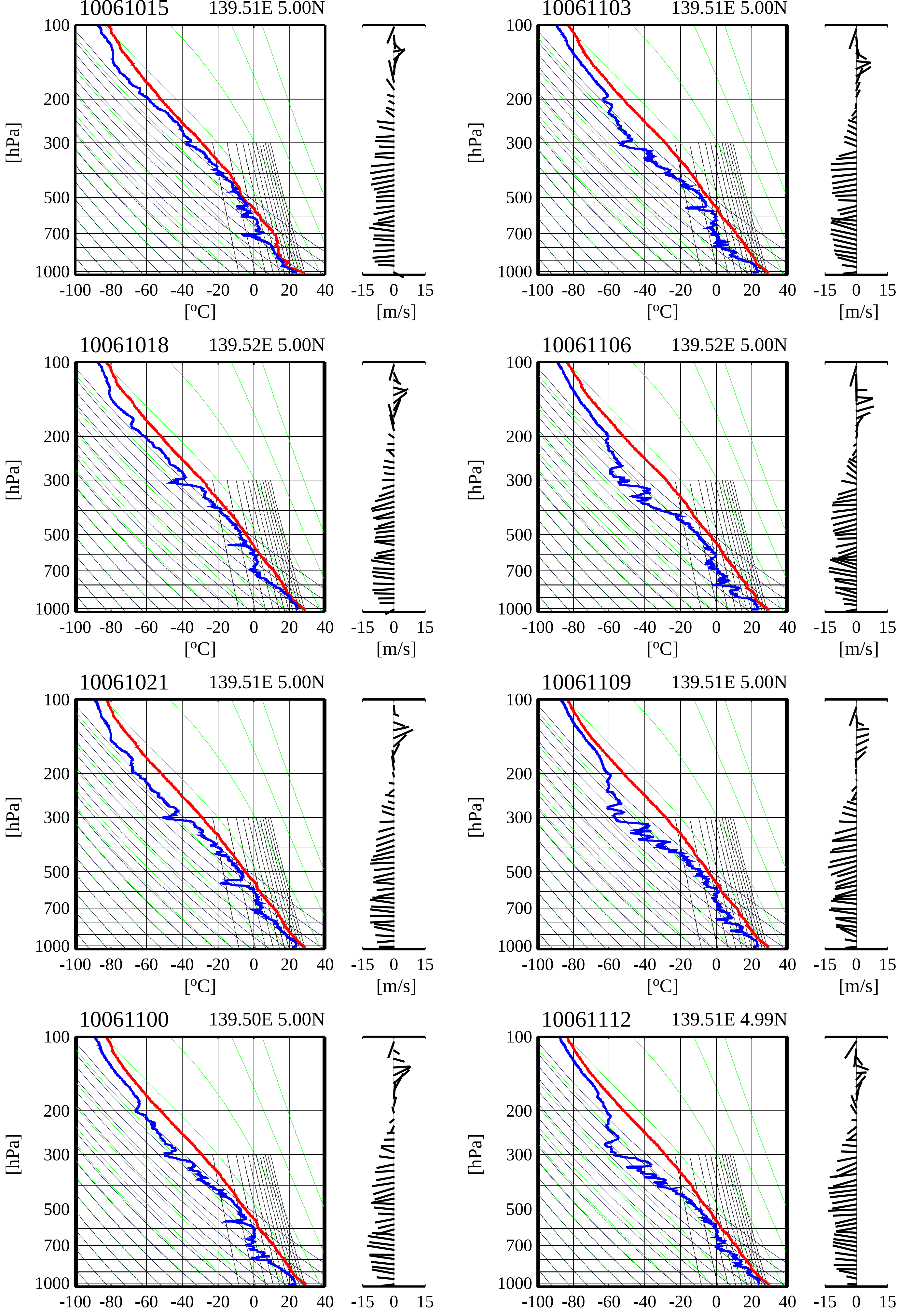
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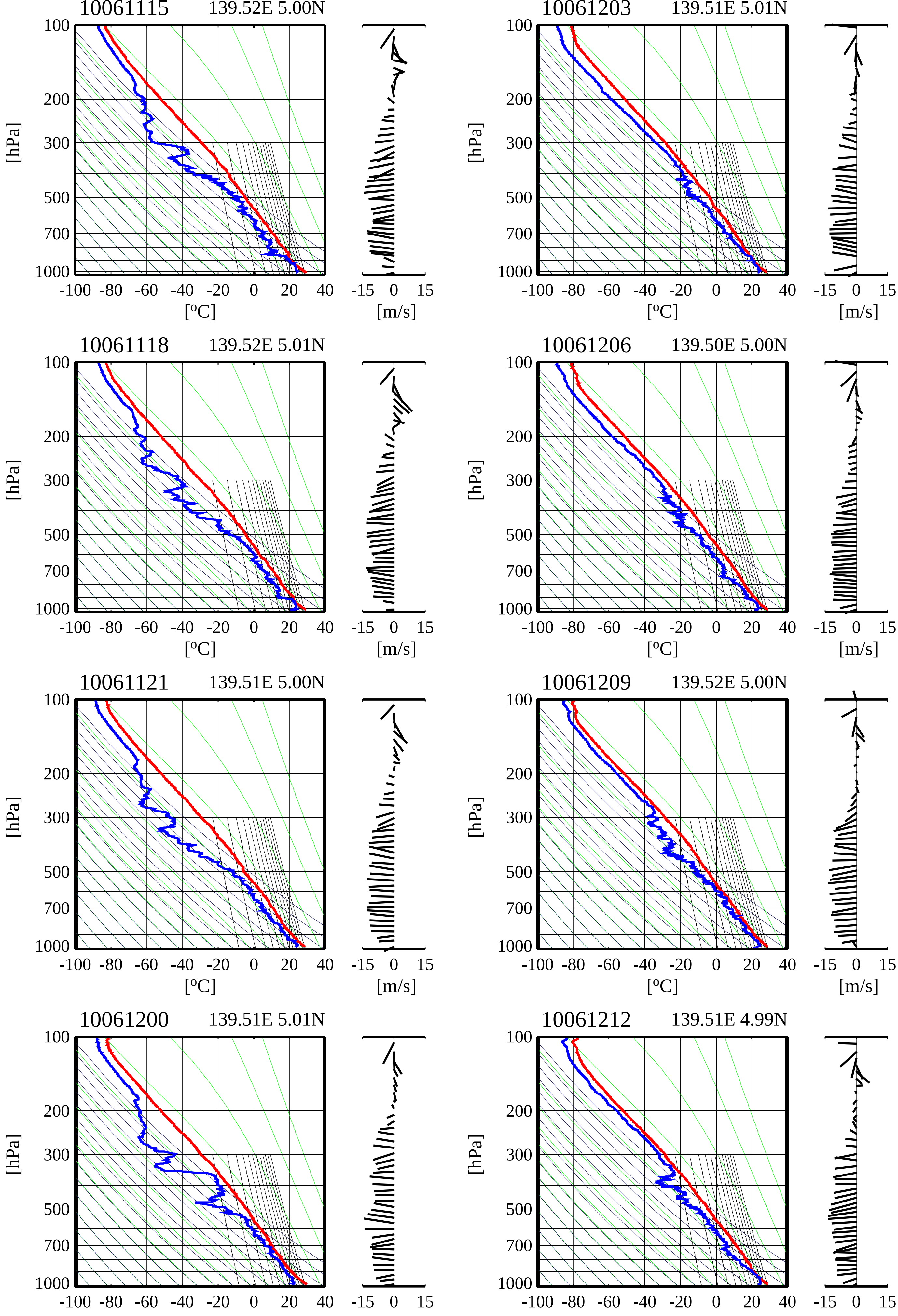
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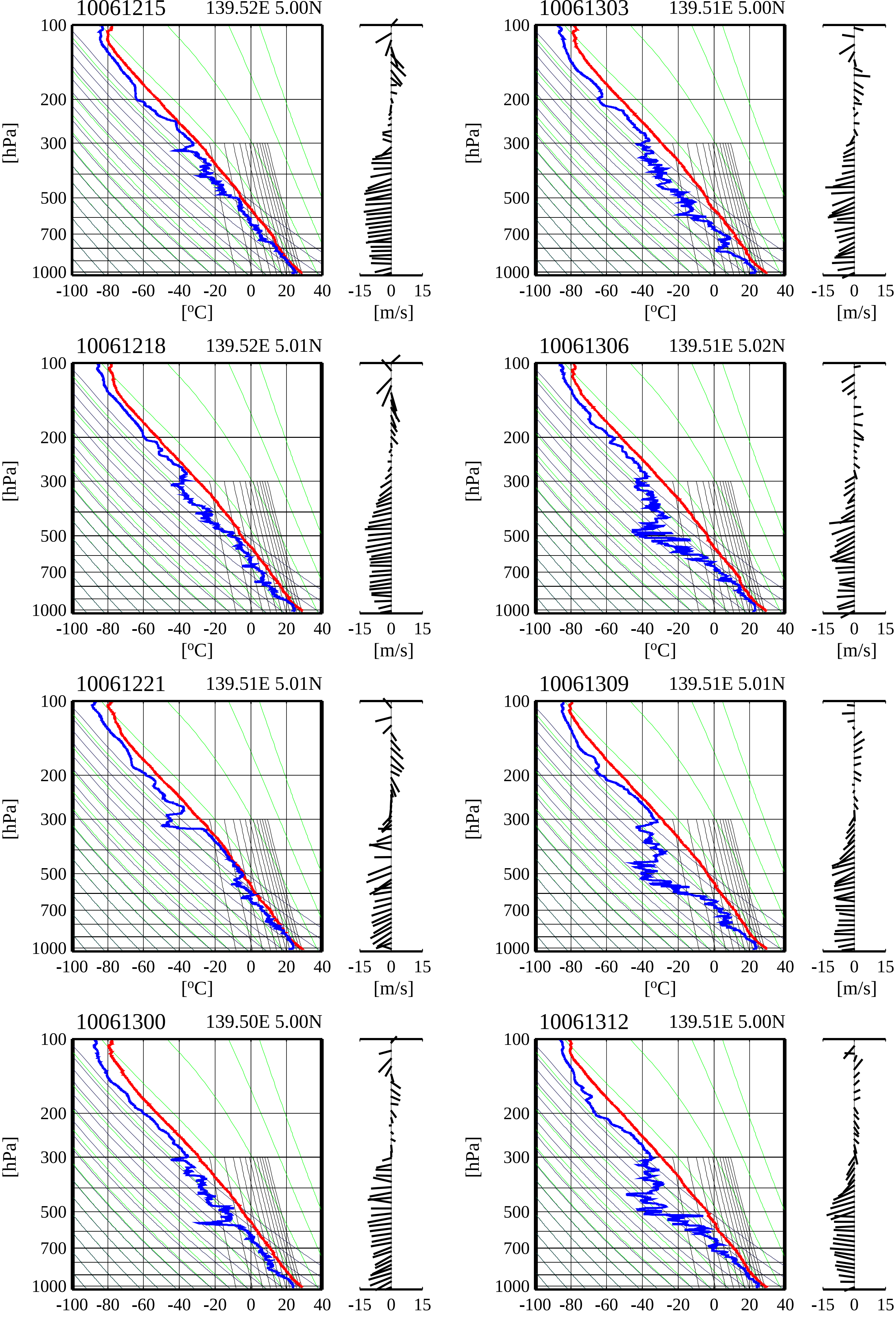

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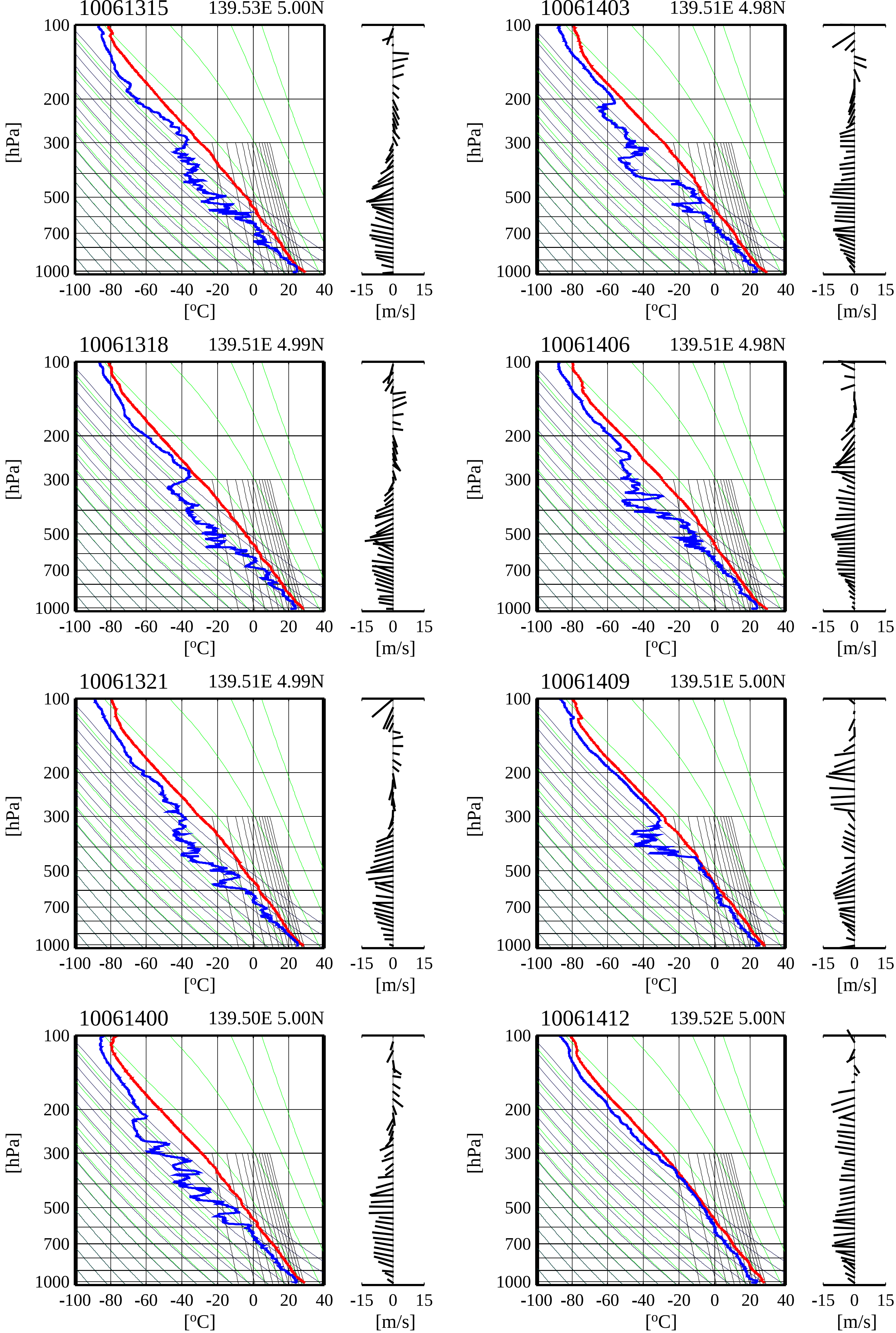
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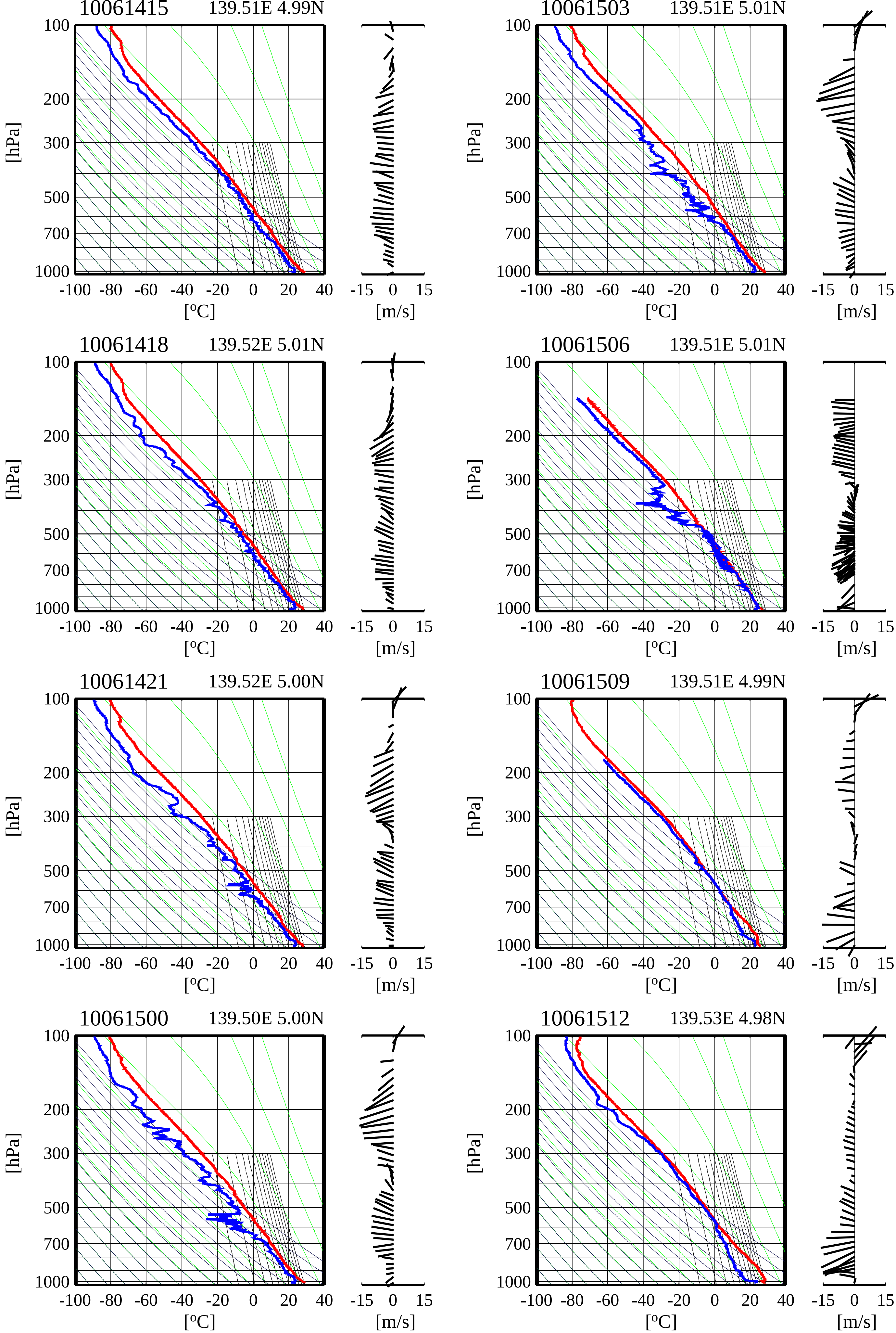
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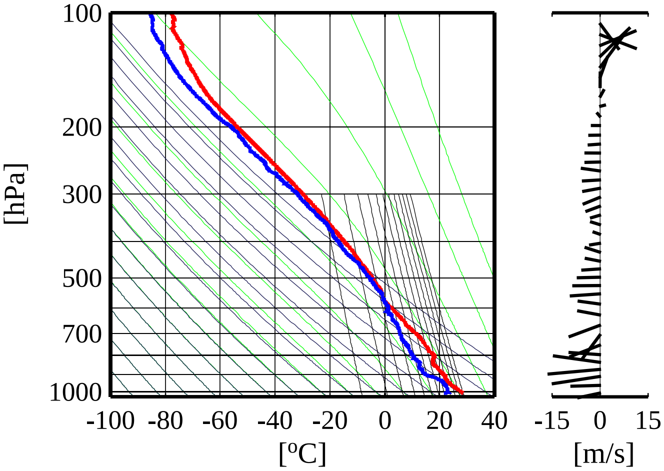

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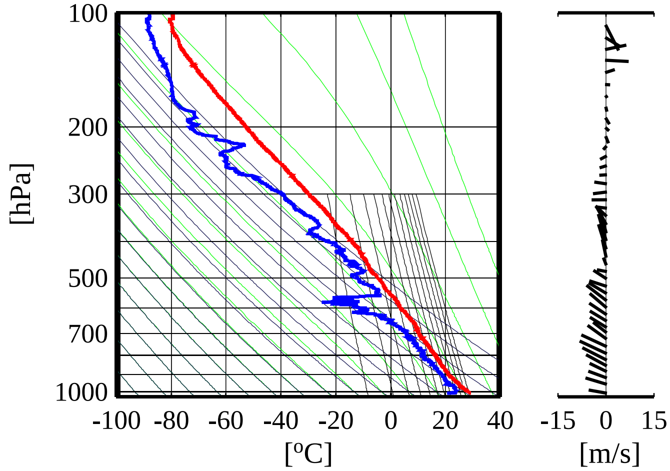

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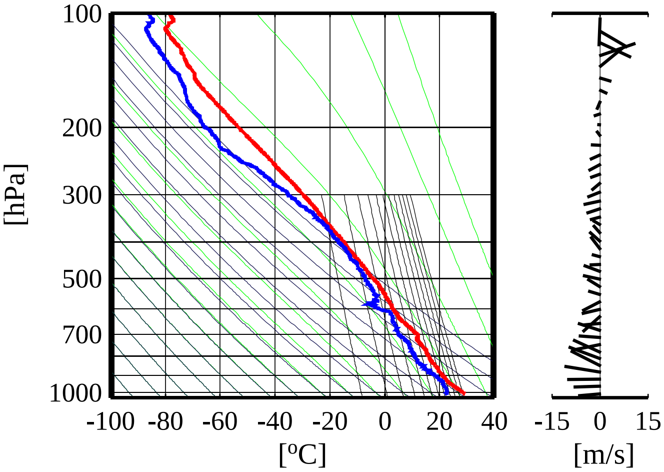

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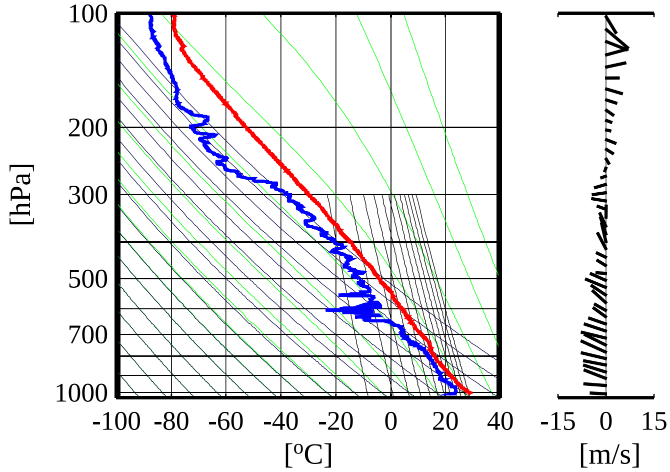

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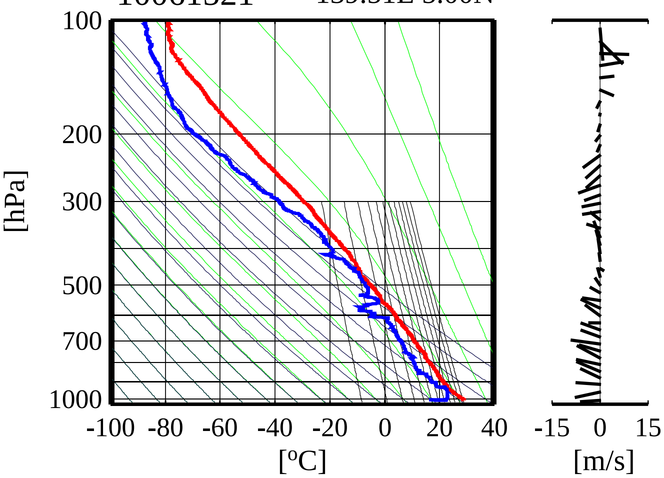

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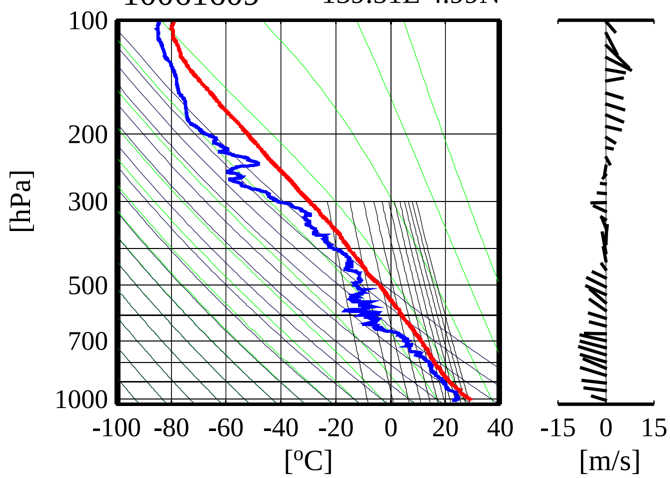

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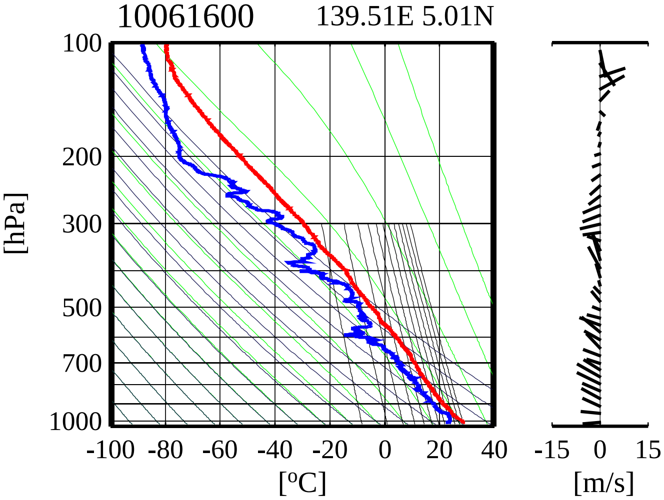

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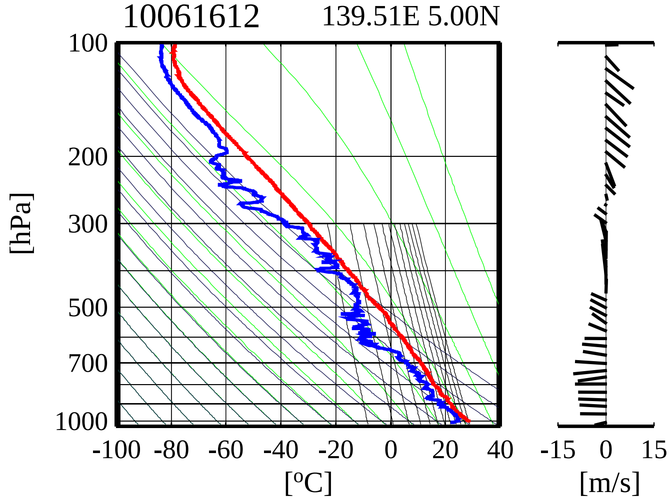

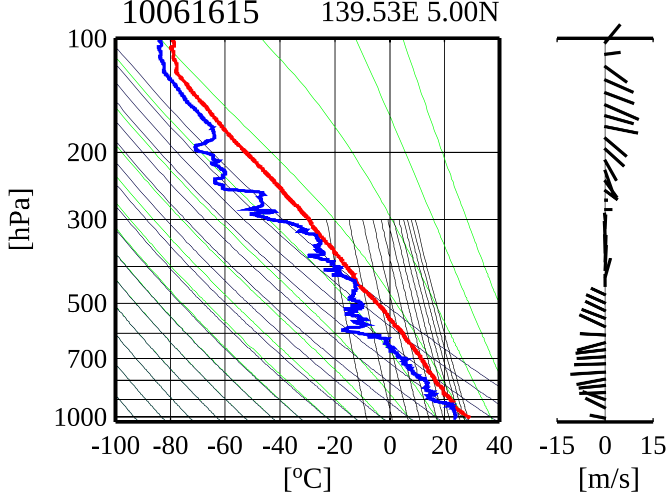
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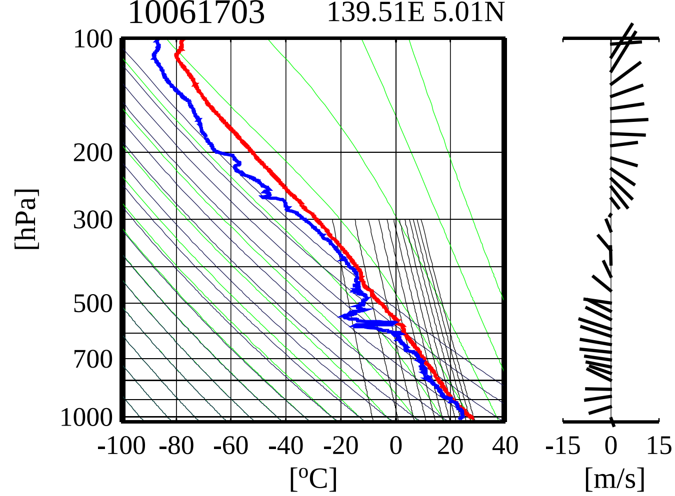
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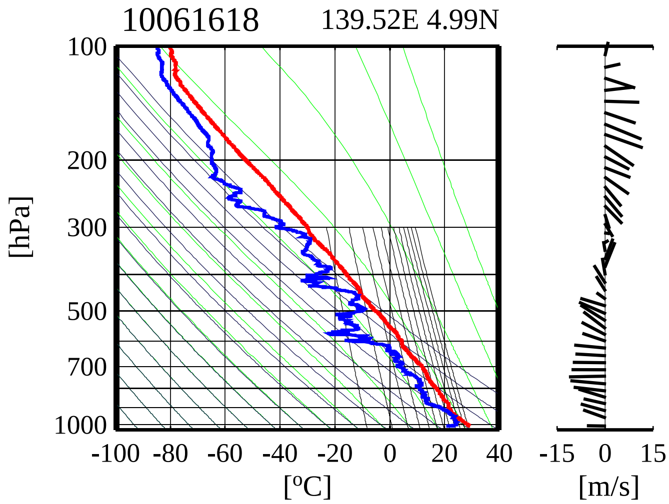
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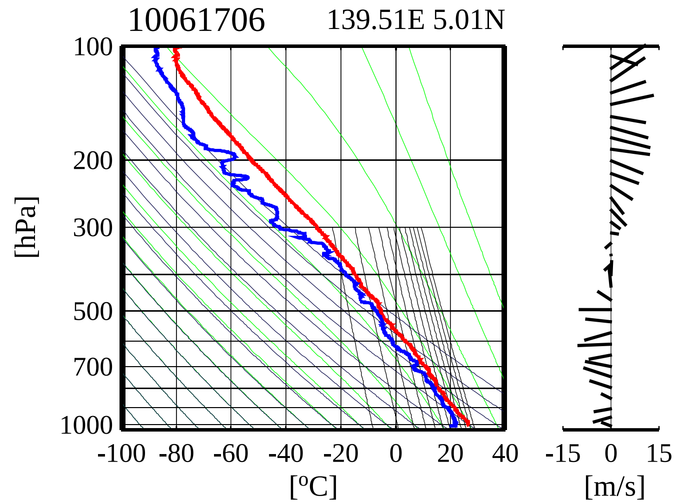
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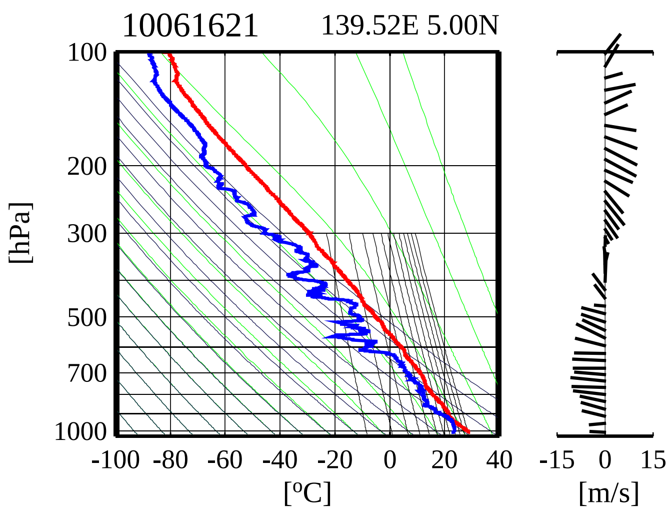
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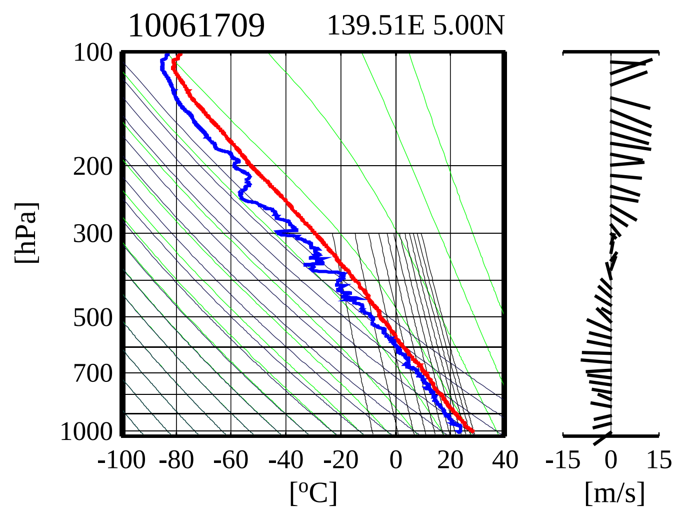
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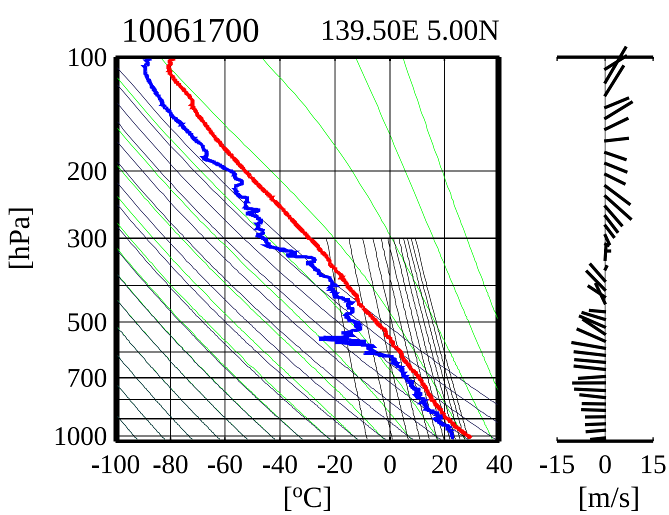
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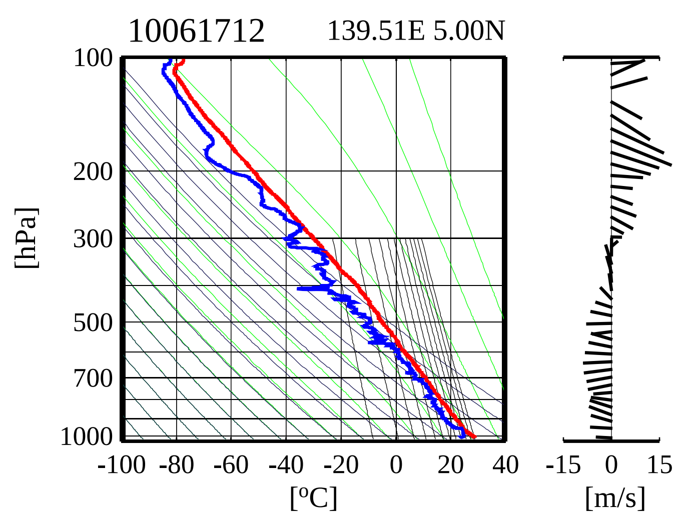
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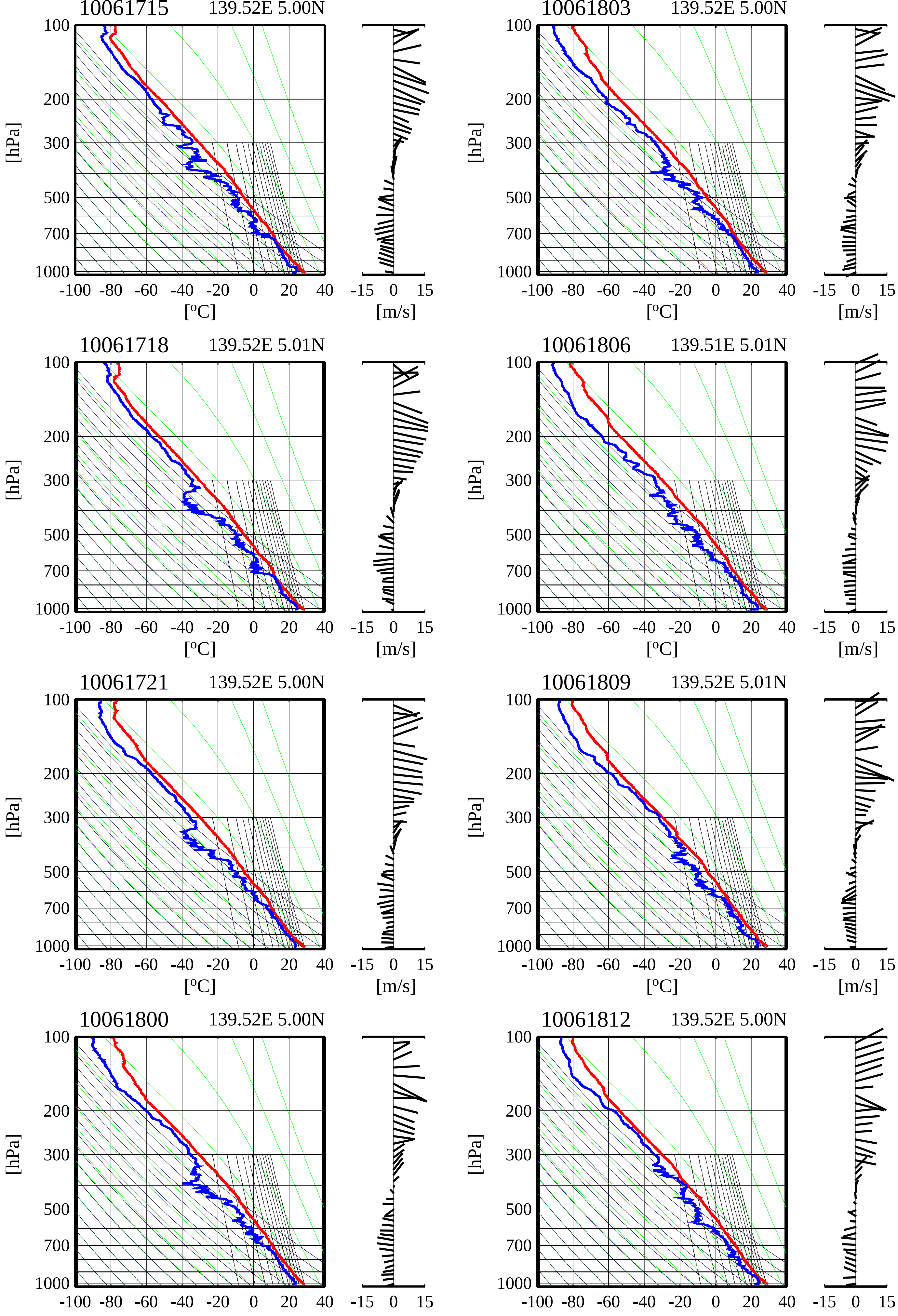
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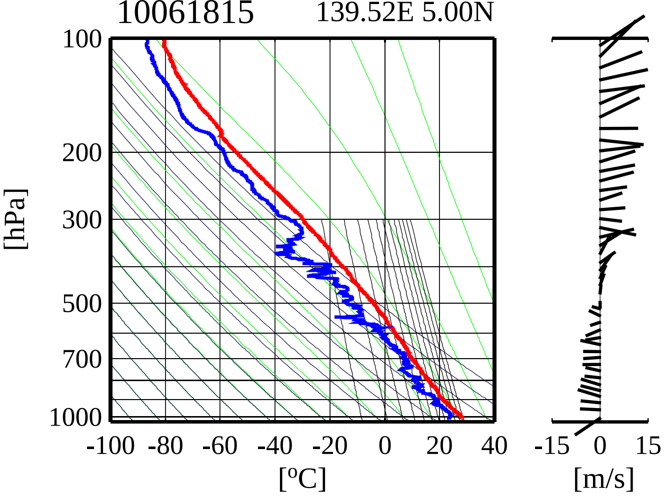
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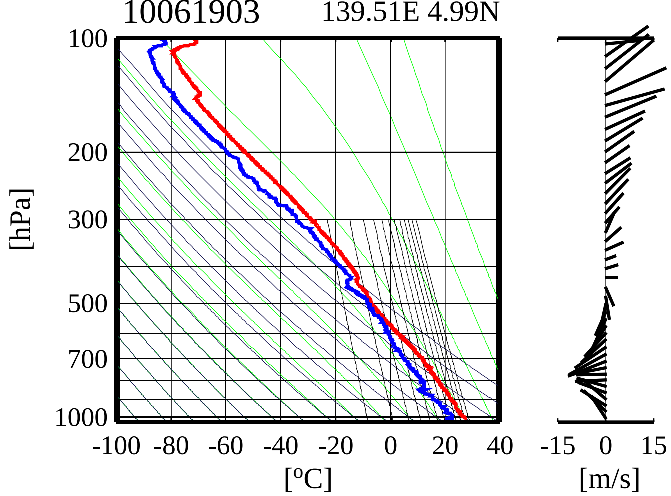
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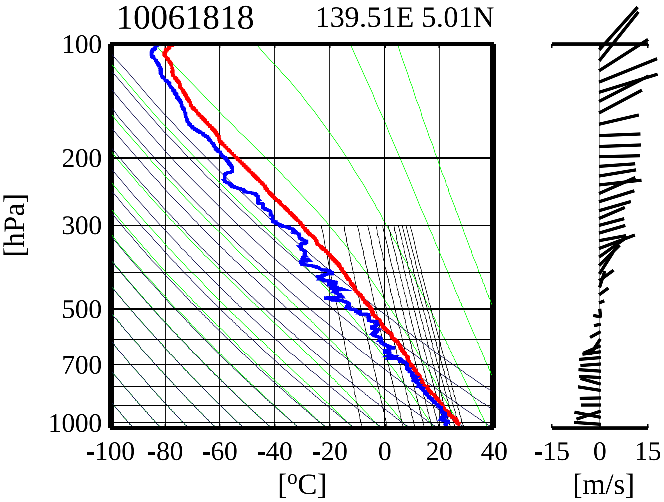
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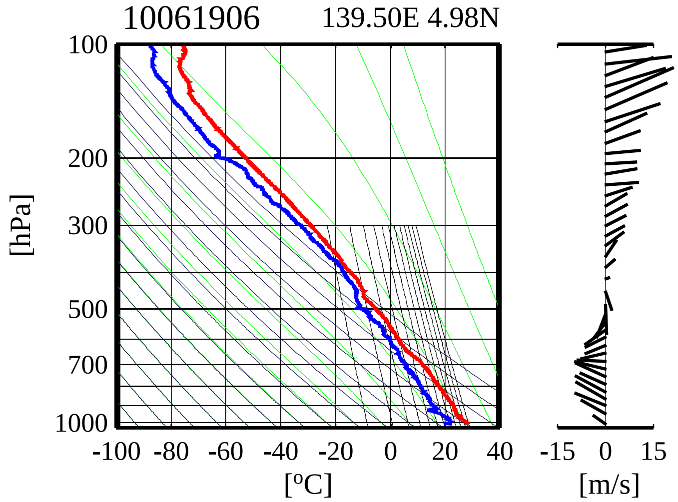
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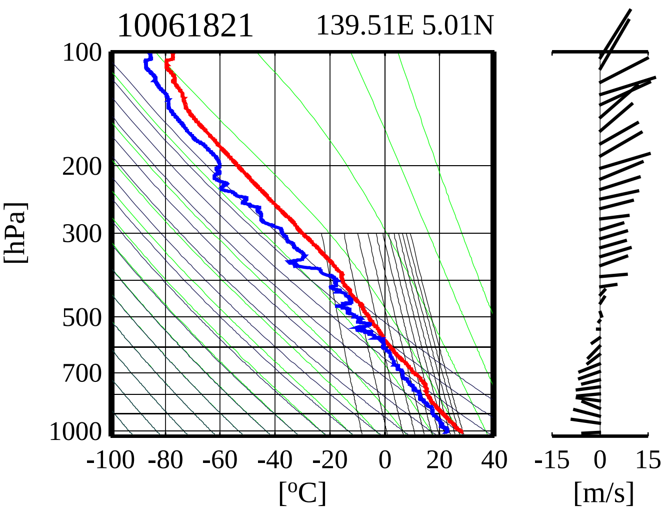
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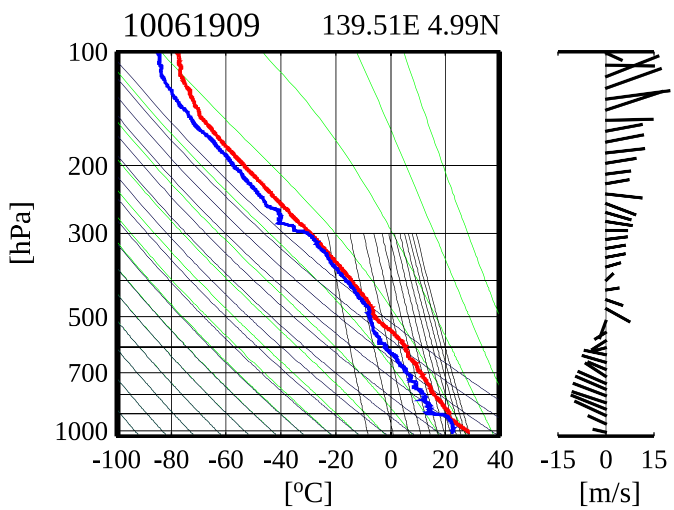
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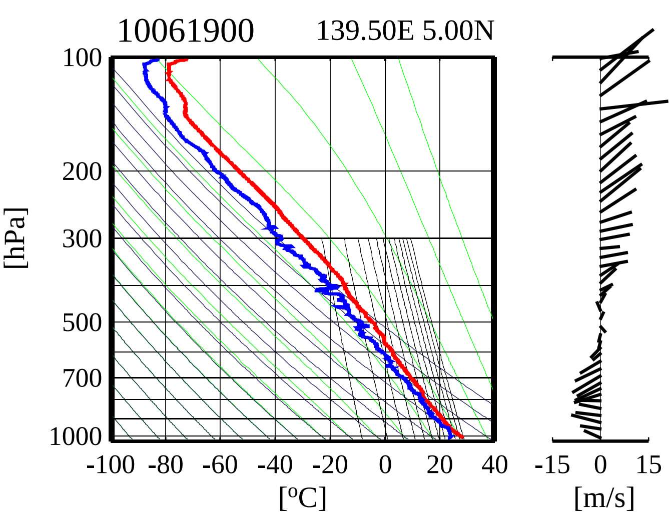
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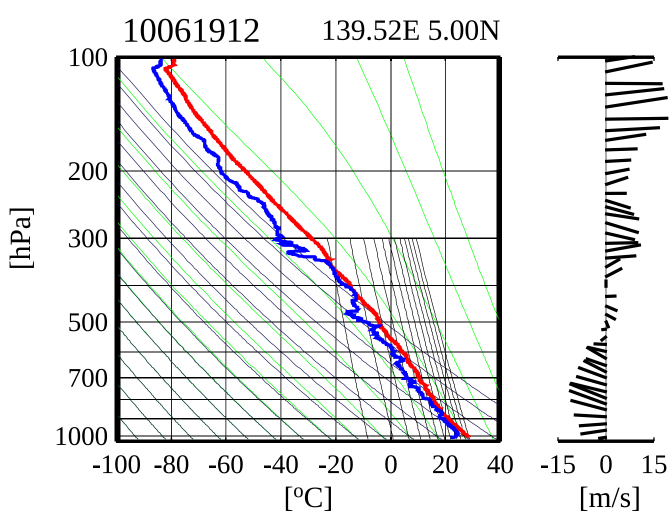
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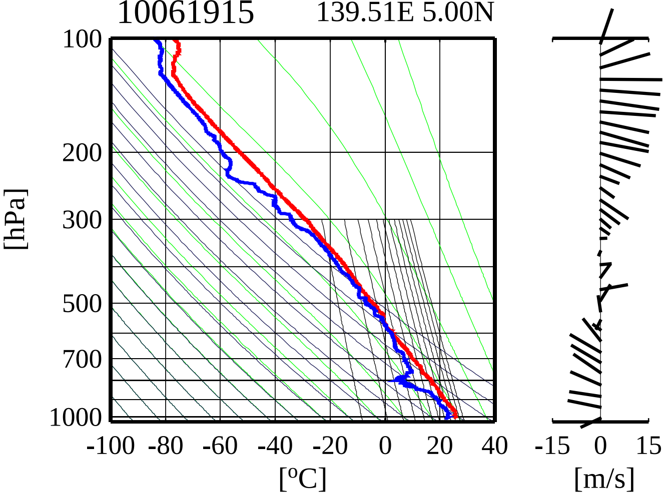
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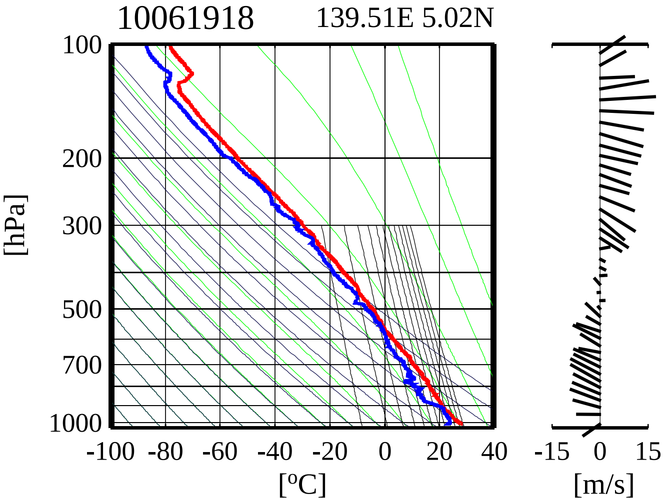
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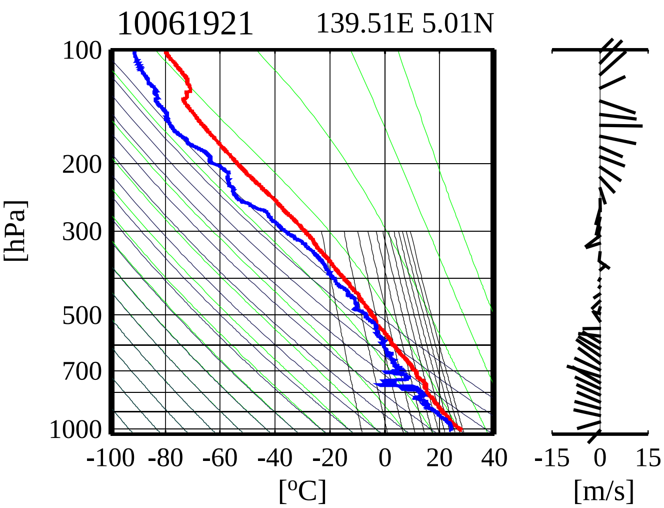
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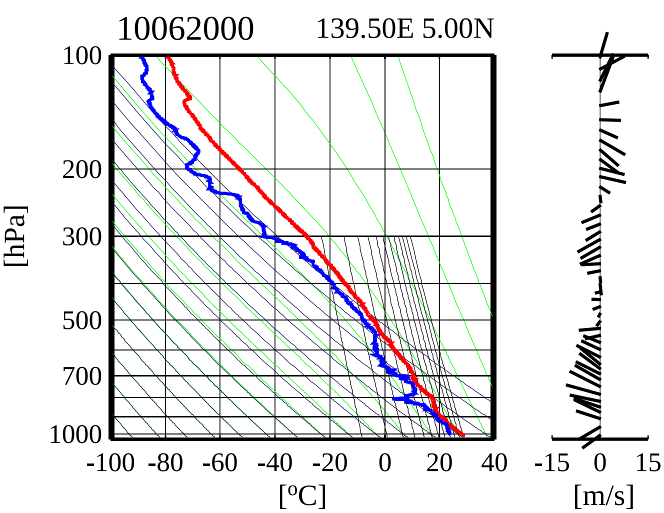
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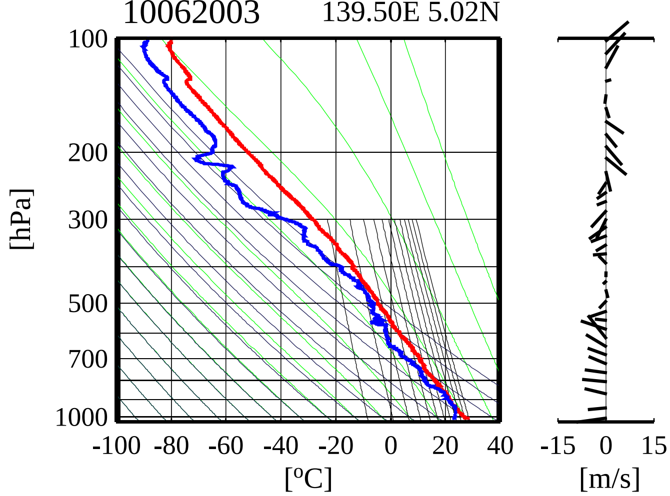
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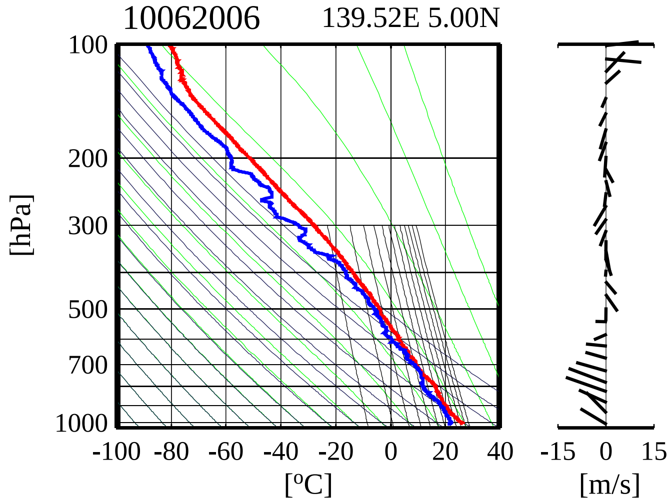
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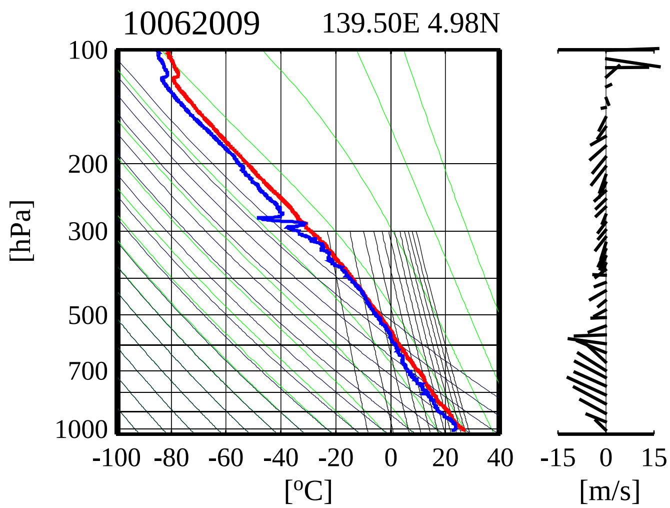
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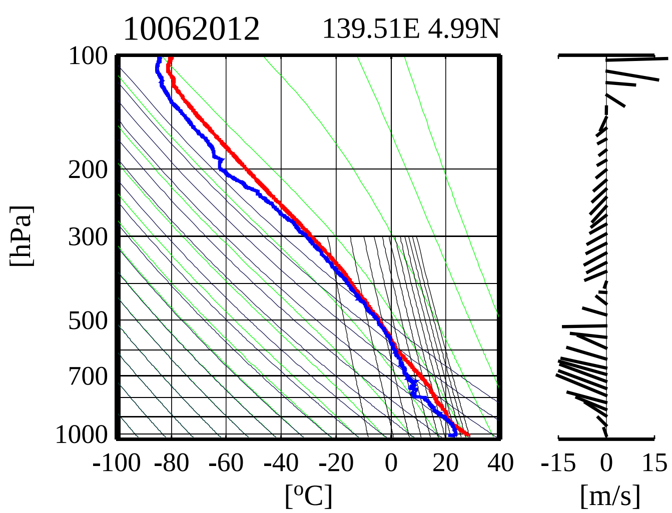
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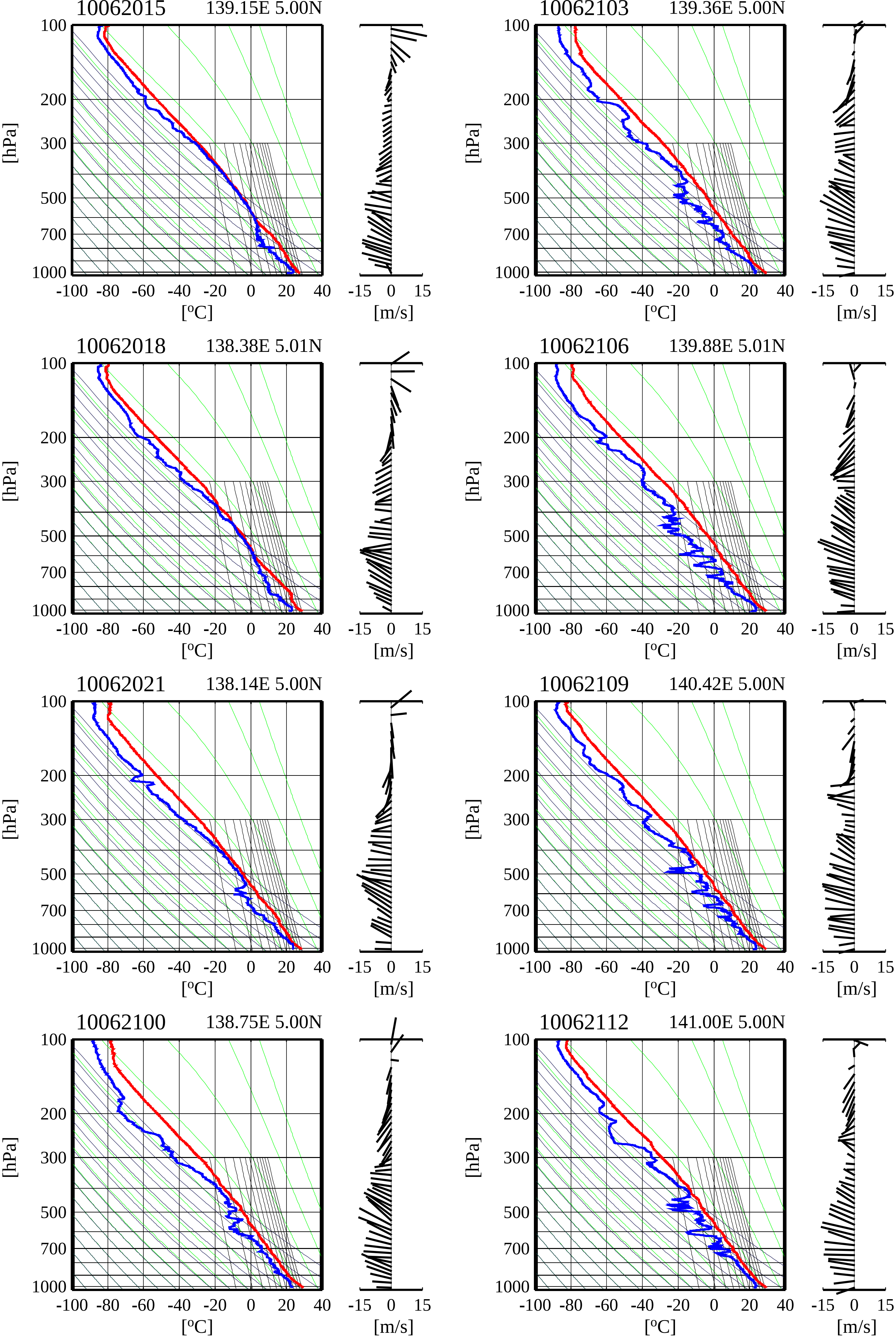
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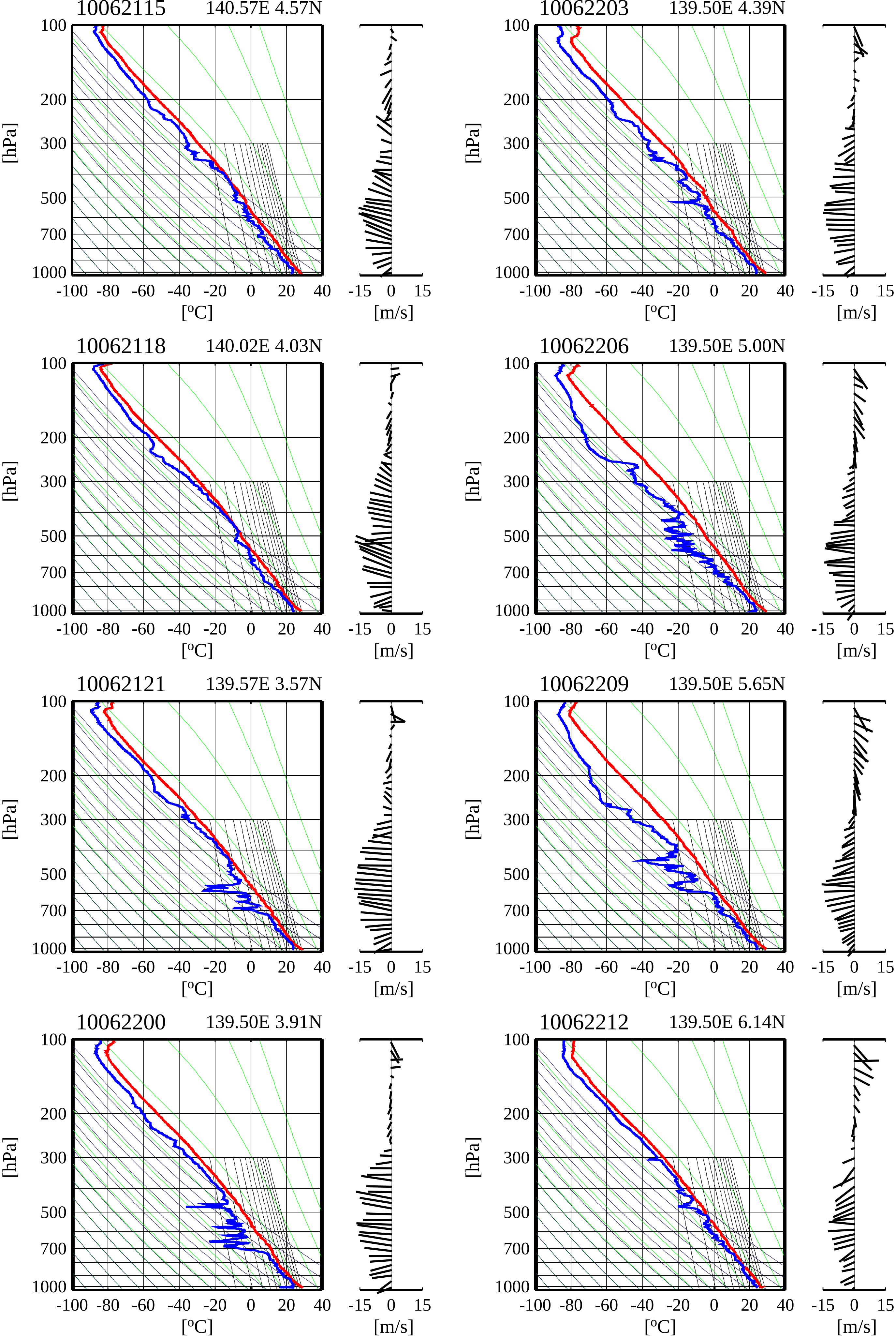
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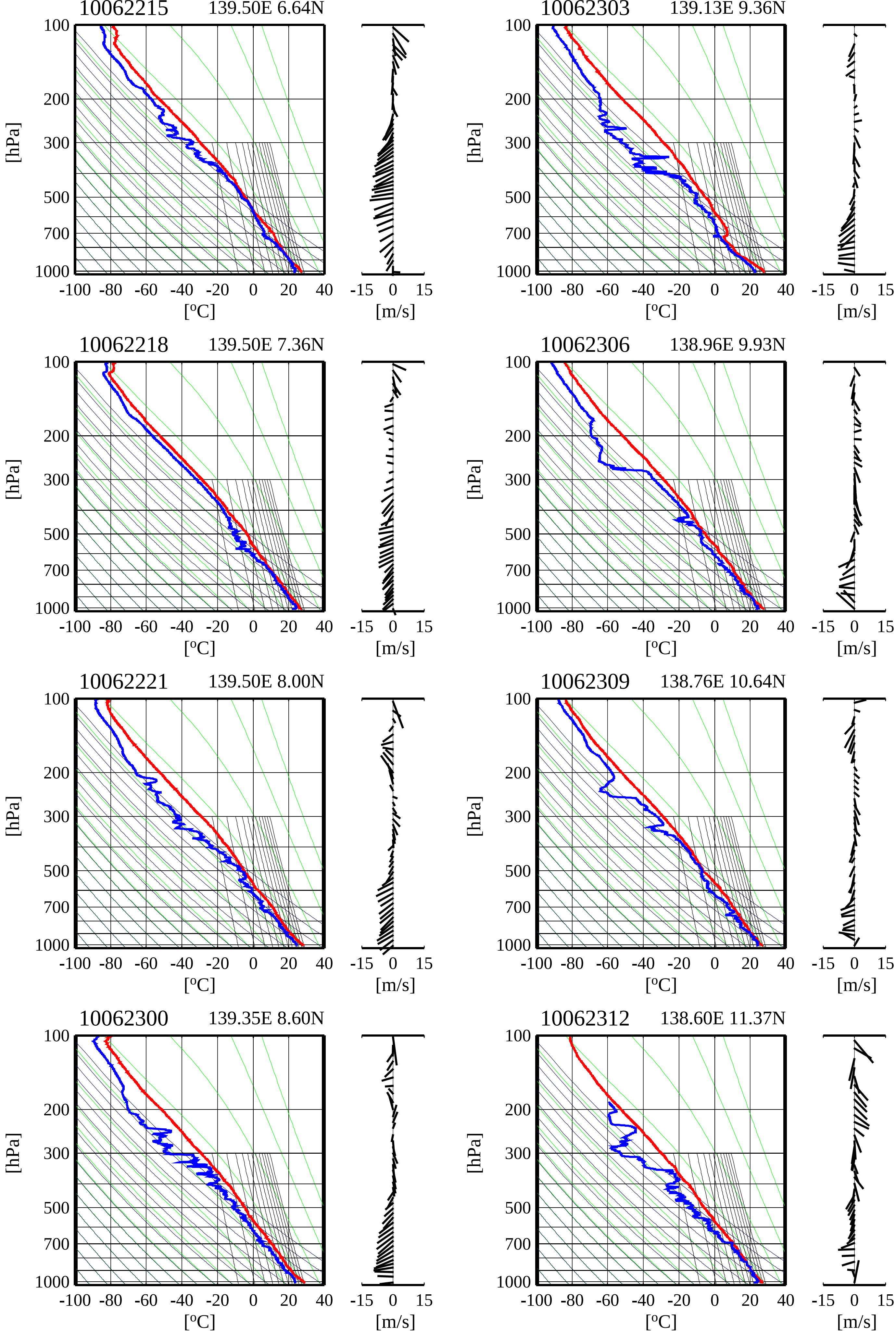
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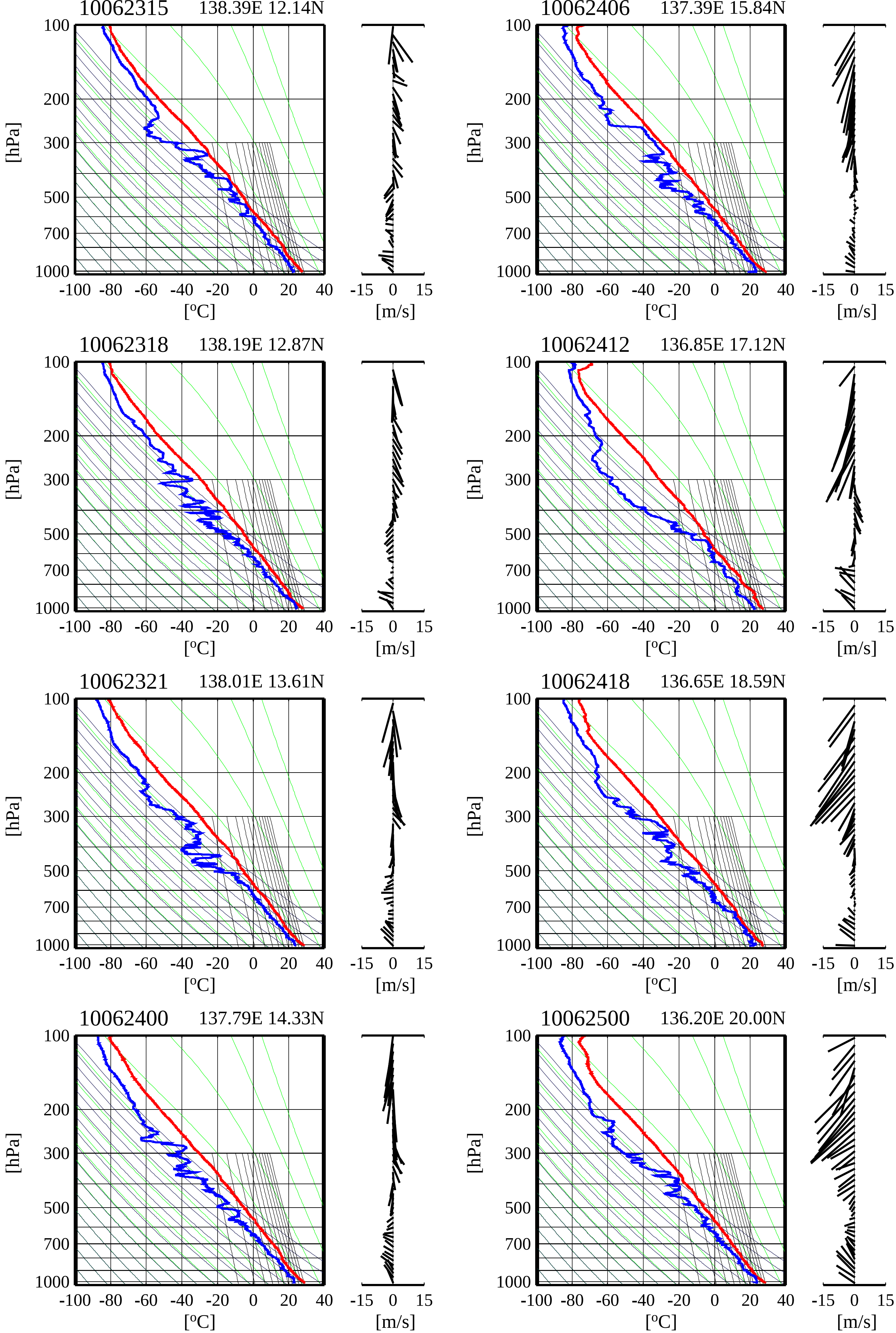
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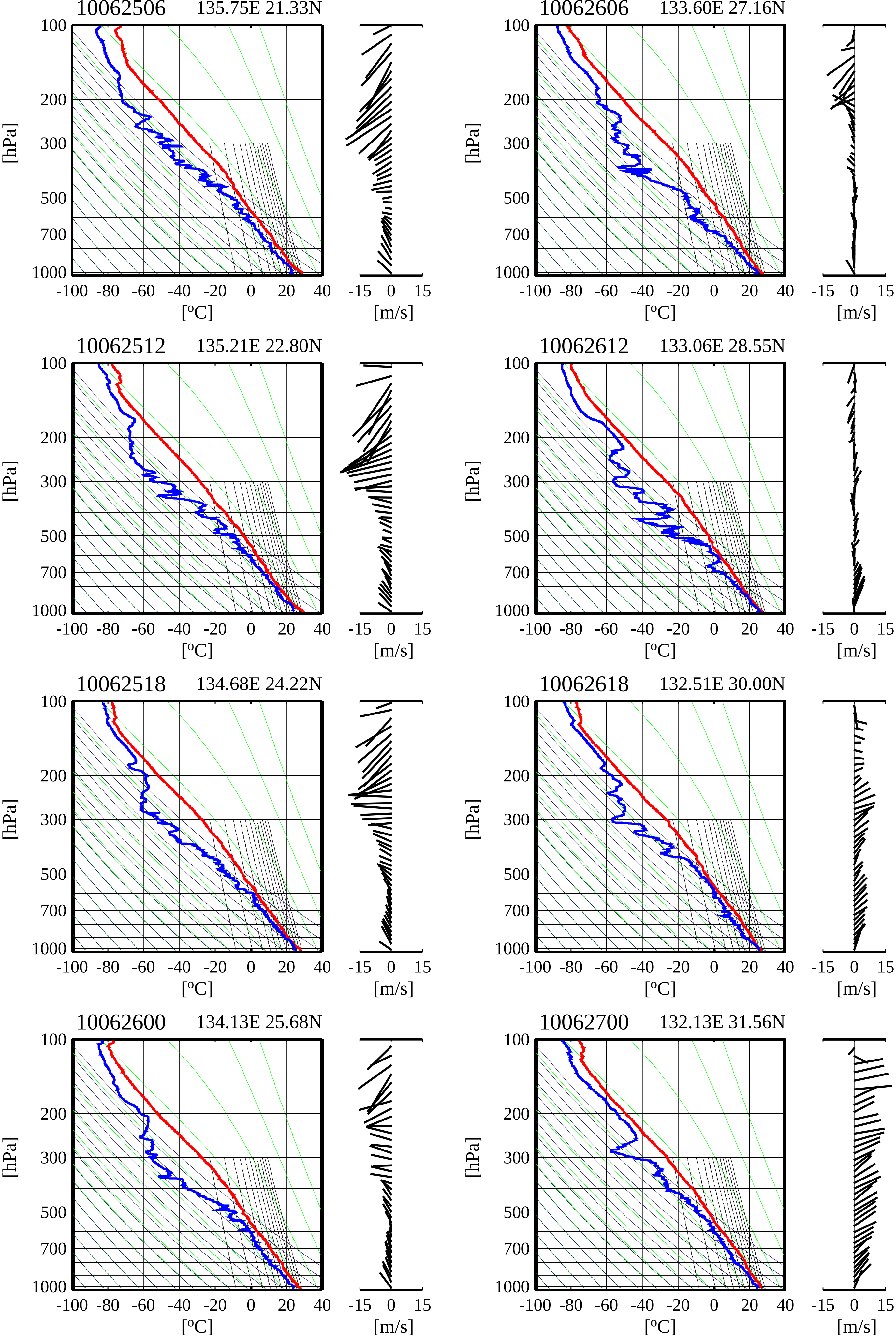
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